KENTUCKY WATER QUALITY REPORT TO CONGRESS

Department for Natural Resources and Environmental Protection
Division of Water (Quality)
Frankfort, Ky. 40601

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INTRODUCTION

Section 305(b) of Public Law 92-500 requires that each state shall submit to the Administrator of the United States Environmental Protection Agency for submission to Congress a report on the quality of the waters in the state. The report contains an analysis of the extent to which the waters meet the goals of the Act, a discussion of point and non-point sources of pollution and an estimate of the cost to meet the goals.

Kentucky has ten major river basins for which river basin management plans are being developed under Section 303(e) of the Act. These plans will be completed by June 30, 1975 and will provide a much greater in-depth study of water quality, cost of meeting the goals and an assessment of point and non-point sources of pollution as well as setting forth a management scheme for upgrading and maintaining desired water quality.

Each river basin is discussed separately as to its unique features and selected water quality and quantity data from the U. S. Geological Survey, ORSANCO, U. S. EPA, U. S. Department of Agriculture, Soil Conservation Service, and the Commonwealth of Kentucky are presented to illustrate the basin and its water quality.

It is evident throughout the majority of the basins that treatment in excess of best practicable treatment for industrial wastewaters and secondary treatment for municipal discharges will be required to meet the goals of the Act due to low flows where stream-flow augmentation is not provided.

The Kentucky Division of Water Quality is charged by law with protecting, preventing, and returning the waters of the Commonwealth to an unpolluted state. The point sources of pollution have been adequately characterized and the effect on the total river miles is not extensive, however, the studies that are being made in conjunction with the river basin planning effort indicates a significant effort in the field of municipal waste treatment and to upgrade those facilities beyond secondary waste treatment will be required to protect the receiving streams for aquatic life. As an overall control program, particular emphasis must be placed on the numerous (over 1,500) discharges which contribute to affecting 1,040 miles of streams. The facilities, for the most part, are located on dry tributaries and extensive treatment facilities will be required or as alternatives the elimination of these facilities by discharging to municipalities or providing land disposal.

The non-point sources of pollution have been described in the report as they affect water quality; effects being principally sedimentation from land erosion with some areas additionally effected by acid mine drainage from coal mining activity. The demand for coal will increase the mining activities in Kentucky by threefold and to that extend considerable effort must be placed in the area of acid mine drainage control and siltage control from mining operation and from coal preparation facilities. A control strategy to combat pollution from non-point sources requires interaction between the U.S.D.A. Soil Conservation Service, the Kentucky Department of Transportation, the Kentucky Department for Natural Resources and Environmental Protection and the Division of Water Quality. Water quality Management Strategy for both point and non-point sources is being developed in Section 303e and this management effort must be supported by additional water quality characterizations through compliance monitoring, in-stream monitoring and special studies. As the Kentucky Monitoring Strategy is implemented a clearer water quality picture will be presented to assist in ascertaining control procedures needed and to revise the Water Quality Management Strategy.

SUMMARY OF WATER QUALITY REPORTS

Basin	Population	Drainage Area	Population Density	Miles Studied	Total Miles Affected	Miles Affected By Municipalities
Ohio	993,001	6,090	163.1	431	85	36
Big Sandy	112,000	2,285	49.5	560	250	10
Licking	211,000	3,700	57.	1,000	384	89
Kentucky	534,000	7,033	105	868	150	124
Salt	507,233	2,932	173	596	166	67
Green	426,000	8,821	48.3	1,670	214	172
U. Cumberland	260,000	5,077	51	752	176	25
L. Cumberland	92,380	1,900	48.6	360	62	40
Tennessee	68,412	1,000	68.4	248	59	15
Mississippi	56,637	1,250	45.3	275	84	13
	3,261,072	40,088	81.35	6,760	1,630	591

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KENTUCKY GEOLOGICAL SURVEY

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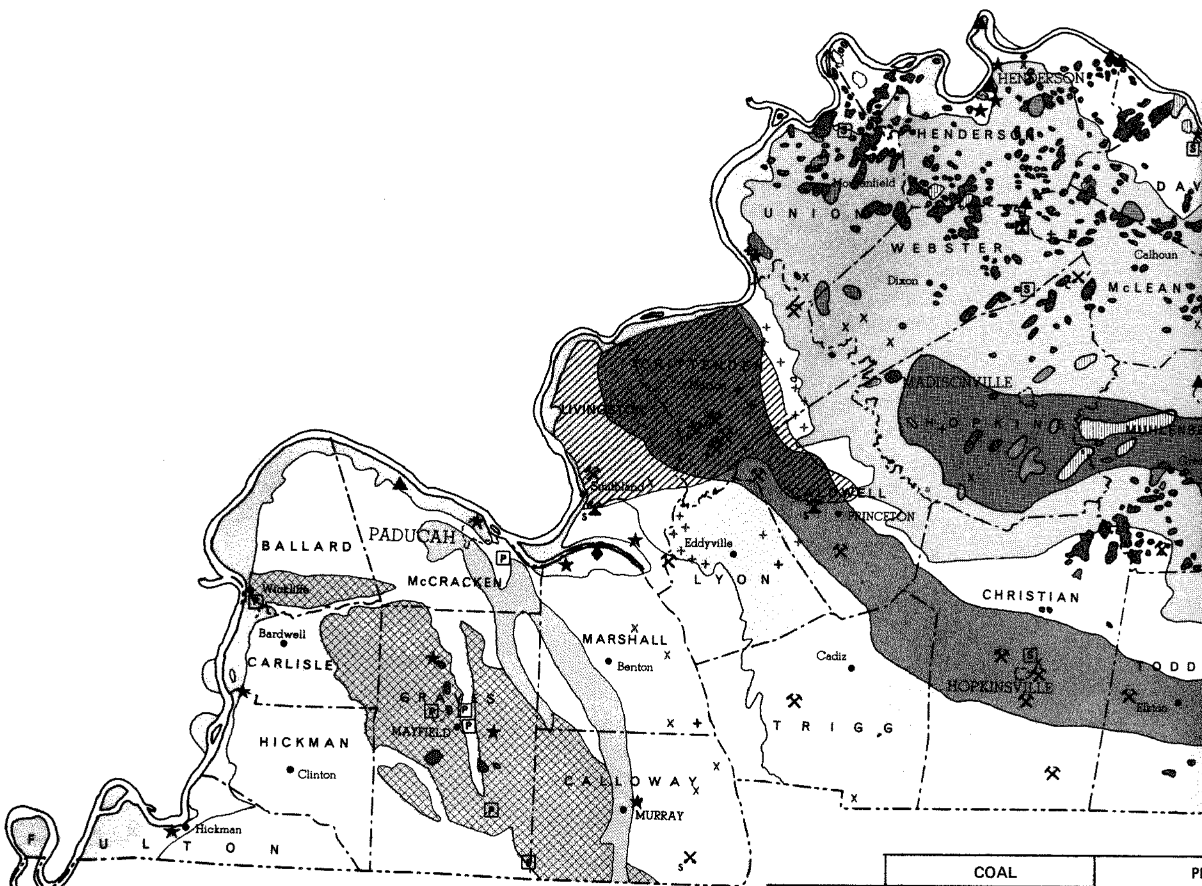

	COAL	PE
RESOURCES	COAL FIELD	In recent years s primarily water f fields have becor the recovery of depleted or aba shown.
INDUSTRY	PRINCIPAL PRODUCING AREA	P P
PRINCIPAL INDUSTRIAL PLANTS	▲ ELECTRIC STEAM GENERATING STATION COKING PLANT	● R

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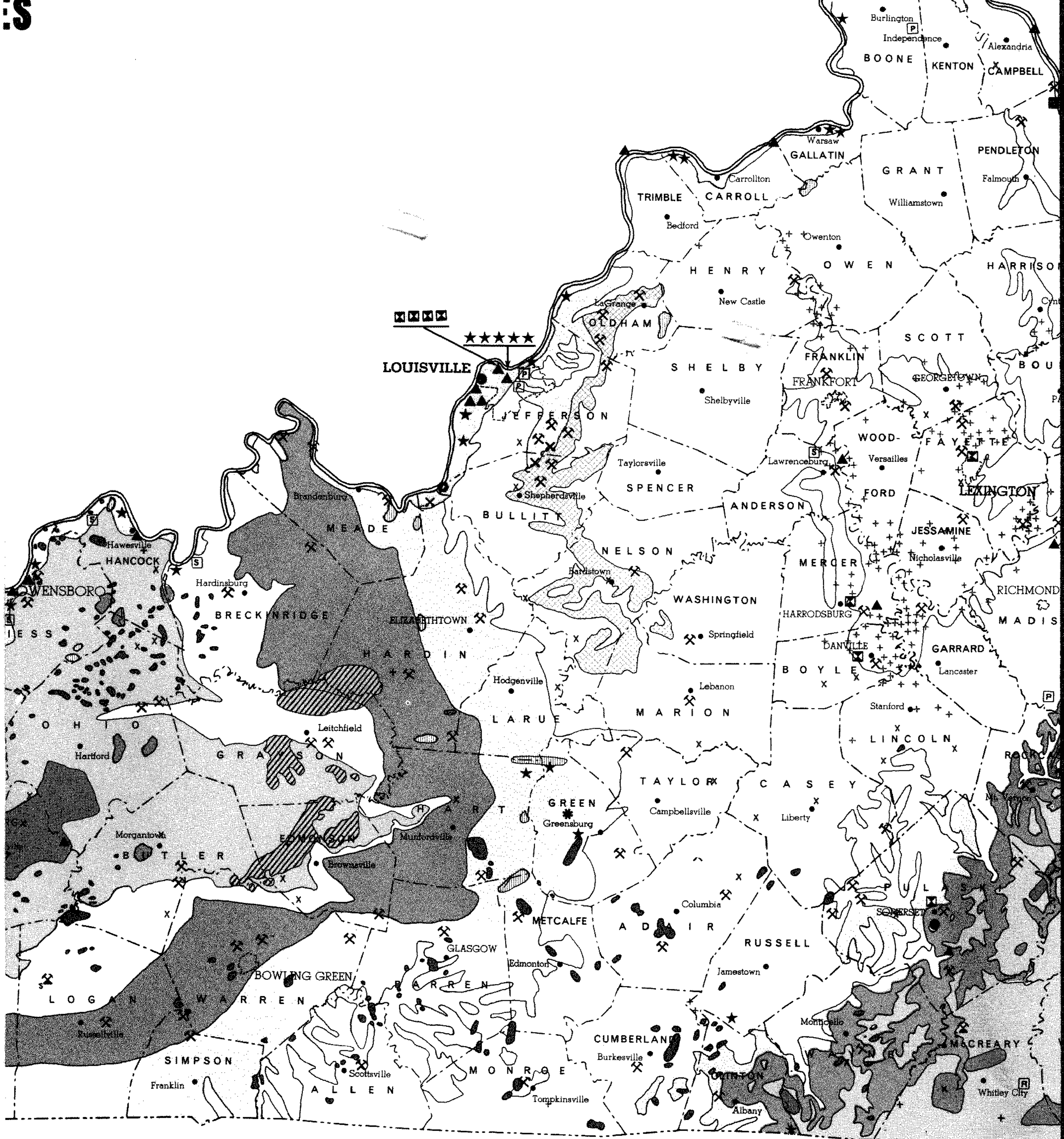
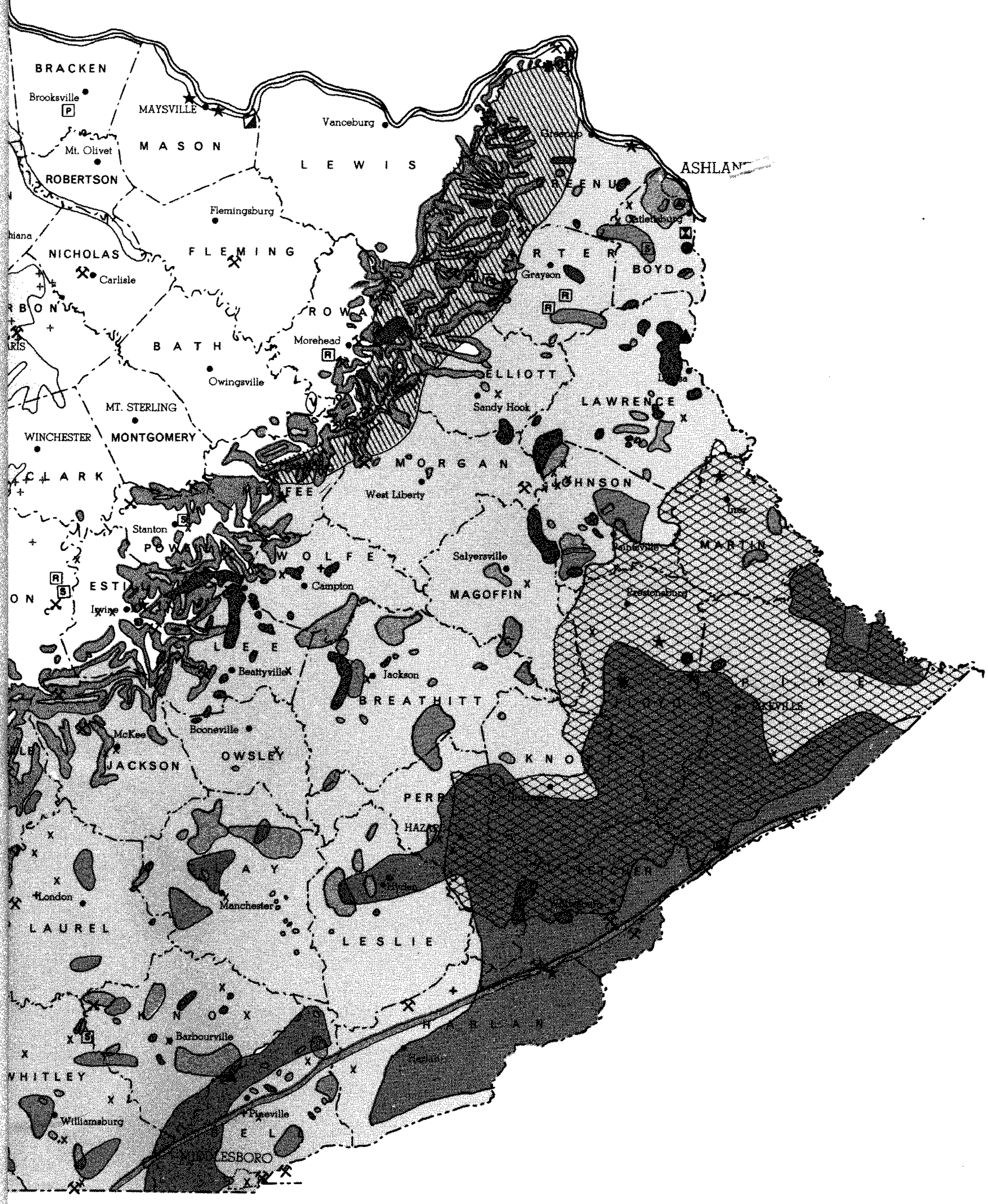


TROLEUM	NATURAL GAS	LIMESTONE and DOLOMITE	CLAY and SHALE	SAND-GRAVEL and SANDSTONE	FLUORSPAR and
condary recovery methods- looding-in many of the old ıe increasingly important in oil in Kentucky. The near ıdoned oil fields are not	Ninety percent of Kentucky's annual gas production comes from the Big Sandy gas field in Eastern Kentucky. Depleted fields are not shown.	PRINCIPAL AREAS OF OCCURRENCE LIMESTONE WITH HIGH-CALCIUM ZONES LIMESTONE DOLOMITE	PRINCIPAL AREAS OF OCCURRENCE REFRACTORY CLAY BALL CLAY ABSORBENT CLAY x OTHER TYPES (Analysis available)	PRINCIPAL AREAS OF OCCURRENCE MISCELLANEOUS SAND and GRAVEL (The widespread sand and chert gravel deposits of the region west of Cumberland River are not included.) + HIGH-SILICA SAND or SANDSTONE (Analysis available)	PRINCIPAL WESTE FLUOR (With a Pb, Ba + REPOR MINER
RINCIPAL RODUCING AREA	BIG SANDY GAS FIELD OTHER GAS FIELDS STORAGE FIELD	CRUSHED STONE QUARRY or MINE	PRINCIPAL PRODUCING AREA OPERATION OUTSIDE PRINCIPAL CLAY AREA	★ SAND and/or GRAVEL OPERATIONS SANDSTONE QUARRY SILICA SAND OPERATION DIMENSION STONE QUARRY	FLUOR
EFINERY	HYDROCARBON RECOVERY PLANT	LIME PLANT LIME PLANT (Under construction) CEMENT PLANT	R REFRACTORY S STRUCTURAL P POTTERY	GLASS PLANT	◆ FLUOR



OTHER VEIN MINERALS	ROCK ASPHALT
AREAS OF OCCURRENCE RN KENTUCKY SPAR DISTRICT ssociated minerals- and Zn) TED VEIN AL OCCURRENCE	PRINCIPAL AREAS OF OCCURRENCE (Not presently active)
SPAR MINE	Large reserves of natural rock asphalt occur in Kentucky. These deposits once provided considerable quantities of paving material for highway surfacing. Principal commercial development in the past has been in Edmonson County. Deposits have also been mined in Grayson, Breckinridge, Hardin and Logan Counties. Research may revive new interest in the commercial aspects of this material.
ITE PRODUCTS PLANT	

THE MISSISSIPPI RIVER BASIN

The portion of the Mississippi River Basin in Kentucky makes up approximately one half of an area in the far western corner of the State called the Jackson Purchase region (named after General Andrew Jackson who, in 1818, arranged the purchase treaty with the Chickasaw Indians). The Jackson Purchase region is unique in many respects from the rest of Kentucky. This report will discuss first the Mississippi River Basin in general in the region, and secondly discuss existing water quality in the area and the factors that influence water quality in the basin.

I. Basin Description

A. Geography

The Mississippi River forms the western boundary of the Commonwealth of Kentucky from the confluence of the Ohio River at Cairo, Illinois to the Tennessee border. The Mississippi enters Tennessee and in reversing direction, a small area of Kentucky is thus formed and known as the New Madrid Bend.

This basin contains all or portions of the following counties: Ballard, Carlisle, Hickman, Fulton, Graves, McCracken and Calloway and encompasses a total drainage area in Kentucky of approximately 1,250 square miles (Table A-1). Several streams are tributary to the Mississippi River, with their respective areas in Kentucky shown in square miles in parenthesis following the names of the tributaries. They are: Mayfield Creek (438.0), Obion Creek (319.0), Bayou du Chien (214.0), and Obion River (146.0). An additional 138.0 square miles are directly tributary to the Mississippi River.

B. Topography

The topography of the basin is such that the headwater areas in the watersheds are hilly, resulting in severe sand and soil erosion problems. However as the land approaches the Mississippi River it becomes gently rolling, ending abruptly in a flat flood plain. Elevations vary from 267 to 560 feet above sea level, with average major tributary slopes ranging from approximately 4.0 to 7.0 ft./mi. The main stem of the Mississippi has an average slope in this area of 0.33 ft./mi.

C. Geology

The geology in this area represents four major formation types, made up of sand, clay, gravel, and silt in varying amounts. These are situated on a bedrock composed of limestone, chert, and dolomite. Surface waters are given a bicarbonate hardness by this limestone bedrock. Groundwater from this area is generally quite good, although some problems occur depending upon the formation from which it is drawn. Water hardness, pH, and high iron content are the major groundwater problems. The high iron content is encountered most frequently when water is drawn from the bedrock of the area. However, due to the constancy of water quality, temperature, and yield (as high as 1,700 gallons per minute) groundwater remains the major source of domestic and industrial water supply in the Mississippi region.

D. Hydrology

The Mississippi River itself is, of course, one of the most important rivers in the world as it relates to commercial barge traffic. It is under the jurisdiction of the U. S. Corps of Engineers for the maintenance of navigation and flood control. A series of locks and dams and upland storage upstream of St. Louis, along with channel maintenance assure a channel depth of 12 feet from the mouth to the confluence of the Ohio River by maintaining pools and augmenting low flows.

Tributaries to the Mississippi River in Kentucky (excluding the Ohio River), although equipped with flood retarding structures, are not flow regulated or is the flow augmented by dams and reservoirs. Surface water flows, recorded at gauging stations situated along each major tributary give a picture of the hydrology in the region. The flows are listed in the following chart:

Flow Record Summary

Station	Period of Record	Drainage Area	Average Flow	Maximum flow	Minimum Flow	7 day 10 yr. Low Flow
Mayfield Creek at Lovelaceville	34 yr.	212 sq. mi.	231 cfs, 1.09 cfs* / sq. mi.	16,100 cfs, 75.9 cfs / sq. mi.	5.7 cfs, .03 cfs / sq. mi.	7.9 cfs
Obion Creek at Pryorsburg**	21 yr.	36.8 sq. mi.	37.7 cfs, 1.02 cfs / sq. mi.	5,330 cfs, 144.8 cfs / sq. mi.	**	
Bayou du Chien near Clinton	33 yr.	68.7 sq. mi.	90.2 cfs, 1.31 cfs / sq. mi.	9,460 cfs, 137.7 cfs / sq. mi.	4.0 cfs, .06 cfs / sq. mi.	6.3 cfs

* Cubic Feet Per Second

** A low flow partial record station located on Obion Creek near Arlington, Kentucky (203 square miles drainage area) gives a 7 day 10 year natural low flow of 3.3 cfs.

Note: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

The natural low flow in each of these three tributaries is above the average for comparable sized drainage basins in Kentucky. Bayou du Chien has the highest natural low flow in this area of the Mississippi Basin, due to the groundwater contribution to the surface water flow. The groundwater contribution improves water quality in the area due to the greater quantity of water available for dilution wasteloads.

E. Population

The total population (1970) in the Mississippi River Basin in Kentucky numbers 56,637. Mayfield, Kentucky in Graves County, with a population of 10,600, has the largest population in the basin. Ten smaller communities make up the rest of the urban population of 21,380, which represents 38% of the total population. Columbus, Kentucky, a community of 371 people, is the only unsewered community in the basin. The remainder of the population is located in rural areas. The urban distribution is shown in Table A-3. Population in a basin is an important factor in the water quality of the basin, as water is used for a great variety of purposes, then discharged back into the streams.

II. Basin Water Quality

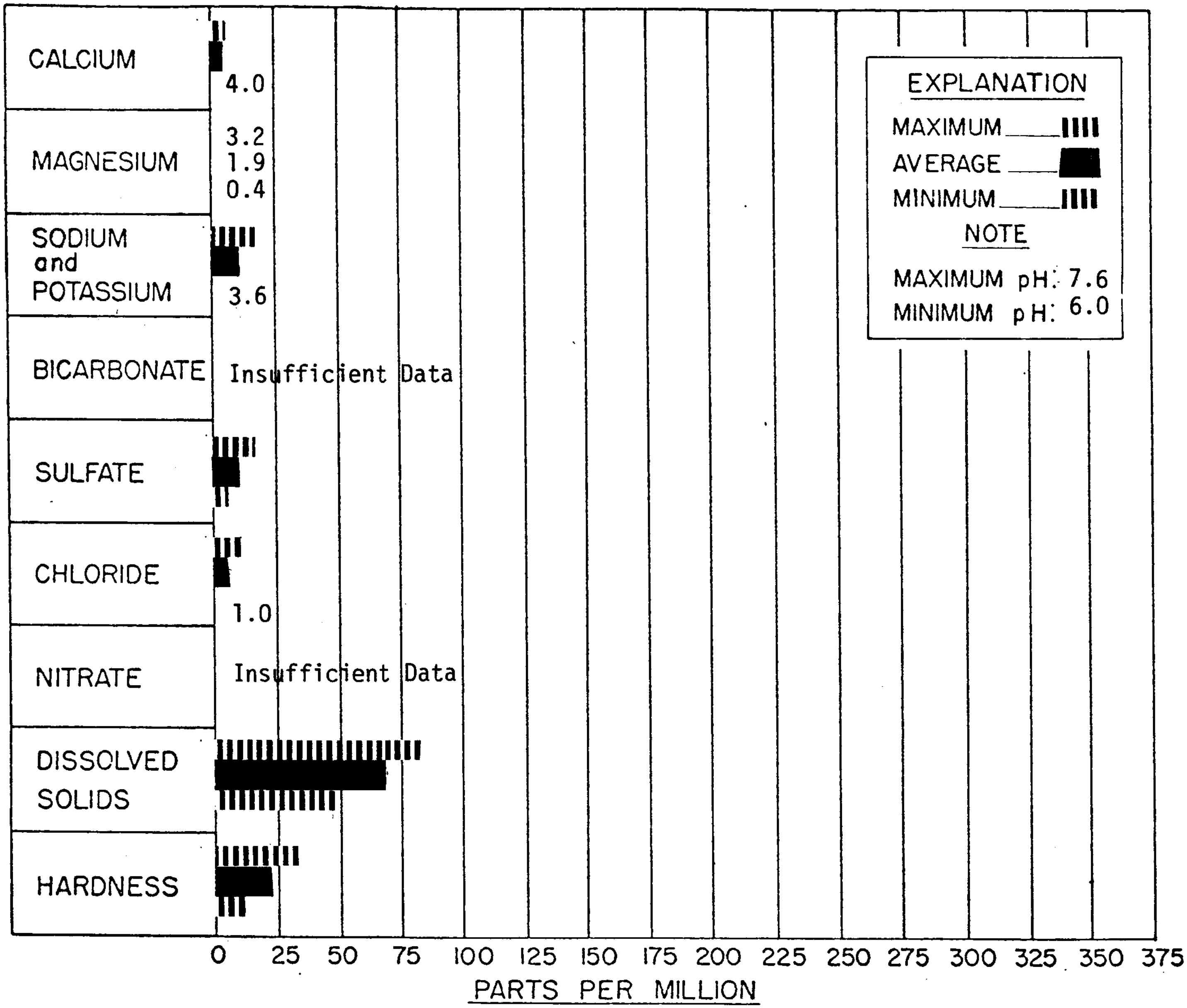
A. Description of Sampling Stations

Samples of the water, for testing its quality, were taken at a U.S.G.S. flow gauging station on Mayfield Creek at Lovelaceville, Kentucky. This is located in Carlisle County, in the north central portion of the basin. Drainage area above the station is 212 sq. mi. representing 17 per cent of the total drainage area in the basin. Data obtained from this sampling point is shown in Table A-4 and presented graphically in Figure A-1.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

Thence the portion of the Mississippi River Basin in Kentucky, is very soft with a slight bicarbonate hardness. The following information was taken from "Water in the Economy of the Jackson Purchase Region", a Kentucky Geological Survey report. This basin is relatively undisturbed by man's activities which would cause a modification of the General Chemical Water Quality. The water of the region is therefore practically free from the influence of human



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Mayfield Creek at Lovelaceville

Period of Record: 10-60 to 8-72

Figure A-1

related pollutants. For this reason, in all respects the quality of the surface water falls well within normal standards (excepting D.O. at extreme low flow periods) and is considered to be excellent as it is shown on Figure A-1.

C. Trace Chemical Water Quality

Trace elements under 5.0 mg/l are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the Mississippi River Basin in Kentucky were measured as being within Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemical degradable waste impost a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 275.0 miles of streams in the basin that receive waste discharges were evaluated. Based upon present treatment levels and once in 10 year 7 day low flows, there are 84.0 miles of stream where the D.O. concentration may be expected to fall below 5.0 mg/l. Thirteen of the 84 miles of stream are affected by a municipal discharge, 30.3 by industrial, and 40.7 by various other discharges. These distances represent 5 per cent, 11 per cent, and 15 per cent, respectively, of the total stream miles in the basin which were studied. (Table A-5)

E. Non-Point Source Effects

Non-point pollution is a problem in Kentucky's portion of the Mississippi River Basin. The major non-point sources of pollution in the basin are summarized below:

1. Land Use: Soil erosion from 273 square miles (22 per cent of basin area) of farm land is considered excessive. Logging operations, burning, and grazing in 56 square miles (.05 per cent of basin area) of forest land has resulted in severe soil erosion in the area.

2. Animal Wastes: All agricultural feedlots in Kentucky have a capacity of less than 1,000 animal units and, therefore, no NPDES Permits have been issued in Kentucky for feedlots. Kentucky has developed a manure lagoon disposal system in cooperation with the USDA-SCS which is currently under study and is used by some feedlots. These lagoon systems have been employed in the Mississippi River Basin and have minimized the waste load effect from feedlots when properly operated.

3. Urban Runoff: Mayfield, Kentucky is the only city which could influence water quality from urban runoff. The effect of urban runoff should be partially mitigated through a unique sanitary sewer overflow lagoon which acts as a detention and treatment basin before discharging to the main sewage treatment plant for further treatment. The overflow lagoon was a cost effective solution to a severe inflow/infiltration problem rather than eliminating stormwater access to the sanitary sewer system.

F. Water Uses

Surface and groundwaters in the Mississippi River Basin in Kentucky are used for public water supply, industry, fish and wildlife, recreation, and for agriculture. The groundwater of Kentucky's portion of the Mississippi River Basin is of good quality, however, iron removal is needed. The groundwater yield is high (500 g.p.m. and up to 1,700 g.p.m.) and is the source of all of the public water supply in the region. Public water usage is 2.0 million gallons per day (m.g.d.)

Industry, too, relies heavily upon the consistently high quality groundwater as its water source. Except for a large paper mill located directly on the Mississippi River (Westvaco) all of the industry in the basin uses 4 m.g.d. of groundwater for water supply.

There are no major organized recreational areas situated in the basin. However, the quality of the streams in the region is sufficiently high enough to support fish and wildlife, and to allow its recreational use.

Water in the basin is used in the agricultural industry primarily for livestock watering with a small amount used for irrigation.

G. Water Quality Changes

The water quality through the basin is excellent and, therefore, sampling is limited and any change in water quality in the Mississippi River Basin in Kentucky must be observed over long periods to be meaningful.

III. Summary

The water quality in Kentucky's Mississippi River Basin is of high quality. There are some problems related to water quality that require attention. Soil erosion from both farm land and forest land presents a problem of sediment in the water.

Treated wastes discharged from municipal, independent, and industrial sources effect the quality of the basin's streams. The need to upgrade or eliminate waste sources is being determined in the basin planning process. Another aspect of this problem is the need for improved operation and maintenance of waste treatment facilities through a program of operator licensing and education. Kentucky has instituted such programs.

Table A-1
Population in the Mississippi River Basin by County

County	Area (sq. mi.)	1970 Pop.	Area in Basin (sq. mi.)	Pop. in Basin
Ballard	259	8,276	113	5,306
Calloway	384	27,692	17	610
Carlisle	195	5,354	195	5,354
Fulton	203	10,183	203	10,183
Graves	560	30,939	458	27,445
Hickman	246	6,264	246	6,264
McCracken	249	58,281	17	1,475
			1,249	56,637

Note: The information in this table was taken from the 1970 Census as reported in Rand McNally.

Table A-2

Water Withdrawal in the Mississippi River Basin

County-City-Withdrawer	River/Stream	SW	GW	Public (mgd)	Industrial (mgd)
Ballard					
Barlow Mncp. W. W.			x	.036	
LaCenter Mncp. W. W.			x	.1	
Wickliffe Mncp. W. W.			x	.08	
Westvaco	Miss. R.	x			25.0
Calloway	No Major Withdrawal				
Carlisle					
Arlington Mncp. W. W.			x	.02	
Deena of Arlington, Inc.			x	.001	.056
Bardwell City Utilities			x	.11	.012
Fulton					
Hickman Mncp. W. W.			x	.7	
Graves					
Cuba Mncp. W. W.			x	.006	
Fancy Farm Water Dist.			x	.041	
Hickory Water Dist.			x	.075	
Lynch Water Dist.			x	.003	
Lowes - Mrs. John Lowe			x	.005	
Lynnville - Motheral Water Co.			x	.007	
Mayfield Mncp. W. W.			x	.66	.49
Beadleton Comm. W. System			x	.005	
Hardeman Water Dist.			x	.018	
Dairy Brand of Mayfield, Ky.			x		.012
General Tire and Rubber Co.			x		3.2
Pet Milk Co.			x		.25
Sedalia Water Dist.			x	.014	
Tri-City - Mrs. Myrtle Casey			x	.004	
Water Valley Mncp. W. W.			x	.075	
Wingo Mncp. W. W.			x	.092	.005
Hickman					
Clinton-Ky. W. Service Co.			x	.11	.013
Columbus Mncp. W. W.			x	.011	
McCracken	No Major Withdrawal				

*Mncp. W. W. - Municipal Water Works

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table A-3

Population Distribution in the Mississippi River Basin

County - City	Population	Federal Assistance	Comments
Ballard			
Wickliffe	1,211	I	Underway
LaCenter	1,044	I	Pending
Barlow	746		
Calloway			
No Major Population Center in the Basin			
Carlisle			
Bardwell	1,049	none	Sewered
Arlington	549	none	Sewered
Fulton			
Hickman	3,049	none	Sewered
Graves			
Mayfield	10,600	I	Pending
Wingo	593	none	Sewered
Fancy Farm	550	I	Underway
Hickman			
Clinton	1,618	none	Sewered
Columbus	371	none	Unsewered
McCracken			
No Major Population Center in the Basin			

*These are all of the cities with a population greater than 300.

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality.

Table A-4

Water Quality Data in the Mississippi River Basin
Data Presented was Collected on Mayfield Creek at Lovelaceville, Kentucky

Parameter	# Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
pH specific units, Kentucky Standard (Ky. Std.) 6 to 9							
	25	6.6	0.4	7.6	6.0	10-60	08-72
Conductivity micro mhos, Ky. Std. 800 micro mhos max.							
	25	92	16	120	53	10-60	08-72
Residue milligrams per liter (mg/l), Ky. Std. 500 mg/l max.							
	22	68	10	82	46	10-60	08-72
Hardness mg/l, 0-60 soft, 61-120 moderately hard, 121-180 hard, over 180 very hard							
	25	22	4	33	12	10-60	08-62
Color units, Proposed E.P.A. Standard 75 units max.							
	19	27	29	135	3	10-60	08-62
Sodium mg/l, No Standard							
	21	8	3	11	2.4	10-60	08-62
Potassium mg/l, No Standard							
	21	2	0.9	5.3	1.2	10-60	08-62
Chloride mg/l, Proposed E.P.A. Standard 250 mg/l							
	25	6	2.2	12	1	10-60	08-72
Sulfate mg/l, Proposed E.P.A. Standard 250 mg/l							
	23	10	3.4	16	6.4	10-60	08-72
Fluoride mg/l, Kentucky Standard 1.0 mg/l							
	22	.2	.1	.5	0	10-60	08-72
Calcium mg/l, No Standard							
	19	5	1	6.6	4	10-60	08-62
Magnesium mg/l, No Standard							
	19	1.9	.6	3.2	.4	10-60	08-62

Table A-5

Organic Loads Affecting Streams in the Mississippi River Basin

Length of streams to which treated organic loads are discharged		275.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		84.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	13.0
	Industrial Discharges	30.3
	Other Discharges	40.7

Note: This information is from the wasteload allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q10-7) low flow.

OHIO RIVER BASIN - MINOR TRIBUTARIES

The minor tributaries to the Ohio River which to be considered are the Tradewater River, the Little Sandy River and Tygarts Creek along with other small drainage basins which have drainage directly to the Ohio River rather than major tributaries. For main stem of the Ohio River of the Water Quality Report has been prepared for the 8 signator states composing the Ohio River Valley Sanitation Commission and this separate report is available on request from ORSANCO, 414 Walnut Street, Cincinnati, Ohio.

I. Basin Description

A. Geography

Since the border of the Ohio River forms the north border of the Commonwealth of Kentucky and is 610 miles in extent; the geography will be discussed in three separate sections. (1) The area from Ashland to Northern Kentucky, (2) the area from Northern Kentucky to Louisville, and (3) Louisville to the mouth of the Ohio.

In the first area (1) there are three tributaries drainage basin; two of which, the Little Sandy and Tygarts Creek, compose about two thirds of the drain basin area from Ashland to Northern Kentucky. This portion of the drainage basin is relatively uninhabited with the exception of three towns over 1,000 population. It is very hilly and activity from crop forming is restricted by the topography.

The second area (2) running from Northern Kentucky to Louisville has one drainage basin with an area of over 100 square miles that is Harrods Creek. The geography of the area is very similar to the first area.

The third area (3) from Louisville to the mouth contains one large drainage basin the Tradewater River. The Tradewater River has a drainage area of 940 square miles. Two other tributaries - Highland Creek and Sinking Creek - have drainage areas of over 100 square miles. Generally, this area has some farm and mining activities; the intense mining activities are in the Tradewater River Basin.

B. Topography

The particular topographic feature which relates to water quality is the slope of the streams. The slope of a stream directly relates to the ability or capacity of the stream for waste load assimilation. The slope relates to the reaeration capability and if the stream has no flow, a direct relationship of the slope to the waste load exists permitting a simple estimate of load which can be discharged into that stream. In area one (1), the slope of the streams is Little Sandy River, 8.3 feet per mile and Tygarts Creek, 6.9 feet per mile. In area two (2), the slopes of the stream is somewhat flater varying from three to four feet per mile. In area three (3), the Tradewater River has an average slope of 1.3 per mile from the headwater to mile point 70. The lower portion from mile point 60 to the mouth is subject to backwater influence of the Ohio River. The lower 70 miles has a slope of 0.7 feet per mile. In area three (3), the slope is generally less than 3 feet per mile for the minor tributaries.

C. Geology

An important geological feature of the Ohio River minor tributaries is a glacial alluvial deposit that extends from a half mile to 5 or 6 miles and forms an important source of groundwater. This groundwater area is particularly important in Louisville where the withdrawal rate exceeds 50 mgd and for Owensboro is the source of the water supply. An unique feature of the Louisville area is the ability to use seepage pits for waste disposal from private residences. This and one other area in the U.S. were known to be sites for such practice. The reason for this is a hard pan layer of clay which prevents the interchange of seepage pit waste into the groundwater aquifer. Another important geological feature is the occurrence of large coal reserves and to extent petroleum resources, with extensive mining in Hopkins County. The coal reserves are shallow and strip mining can be practical for many of the coal seams present.

D. Hydrology

Tygarts Creek and the Tradewater have no locks or dams.

The Little Sandy River has an impoundment near Grayson, Kentucky. The resultant lake, Grayson Reservoir, is used for flood control, recreation, fish and wildlife, and low flow augmentation. The lake has a volume of 10,600 acre feet and an area of 1,500 acres.

Table B-3

Flow Record Summary

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7day 10yr. Low Flow
Little Sandy River below Grayson Dam near Leon, Ky.	9 yr.	196 sq. mi.	248 cfs 1.26 cfs / sq. mi.	5,600 cfs 28.5 cfs / sq. mi.	0 cfs	0 cfs
Tygarts Creek near Greenup, Ky.	35 yr.	242 sq. mi.	301 cfs 1.24 cfs / sq. mi.	14,800 cfs 61.2 cfs / sq. mi.	0 cfs	0 cfs
Tradewater River at Olney, Ky.	34 yr.	255 sq. mi.	342 cfs 1.34 cfs / sq. mi.	13,600 cfs 53.3 cfs / sq. mi.	0 cfs	0 cfs

*Cubic Feet Per Second

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

E. Population

The population of the basin in Kentucky was 993,011 in the year 1970 according to the U.S. Census. The largest city in this area is Louisville with a population of 358,000. Other population centers are Ashland, Northern Kentucky principally the cities of Covington, Newport, Owensboro, Henderson and Paducah. All of these cities discharge into directly the Ohio River and not into these minor tributaries basin. The population in these minor tributaries is predominately urban because of the Ohio River cities. Kentucky has 5 SMSAs and 4 of them are along the Ohio River with the exception of Lexington. As the result of the population concentration and water pollution problems in the Ohio itself, three of these complexes (Louisville, Northern Kentucky and Ashland-Huntington) are being studied under an Areawide Wastewater Management Planning (Section 208 of Public Law 92-500) Urban Studies of the Corps of Engineers.

II. Basin Water Quality

A. Description of Water Sampling Stations

Examination of the character of the water in the minor tributaries was made by selecting two sampling stations. One on Tygarts Creek near Greenup Kentucky was selected since it most closely relates to the water quality through the basin. The other station was selected on the Tradewater River since it reflects the condition of a river which is subjected to acid mine drainage.

B. General Chemical Water Quality - Tygarts Creek and Tradewater River

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The type of rock formation which the surface water contact causes the predominate chemical characteristics when measured over a year period. The contribution of groundwater, which is generally higher in dissolved solids, than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky are ones which have moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases higher than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 -25 parts per million as an average value.

The water quality in Tygarts Creek near Greenup shown in Figure B-1 is typical of the water quality throughout the minor tributaries with the exception of waters which are affected by acid mine drainage. The water in Tygarts Creek is of the calcium bicarbonate type reasonably stable as viewed from the average to the maximum change in water quality slightly on the alkaline side with a pH in excess of a neutral 7. This water is hard but softening for domestic purposes can be done through the line softening process.

The Tradewater River was selected to show the effects of acid mine drainage on a watershed. Figure B-2 clearly illustrates this effect. The sulfate content is excessive with an average value of 260. The total dissolved solids equal those in the water quality standards and the water is extremely hard. Further, this water exhibits very poor stability in that on occasions dissolved solids are five times the average and the pH shows a wide variation from 3.5 to 7.9. This water has very little buffering capacity as shown by the bicarbonate content which has been depleted by acid mine drainage effects.

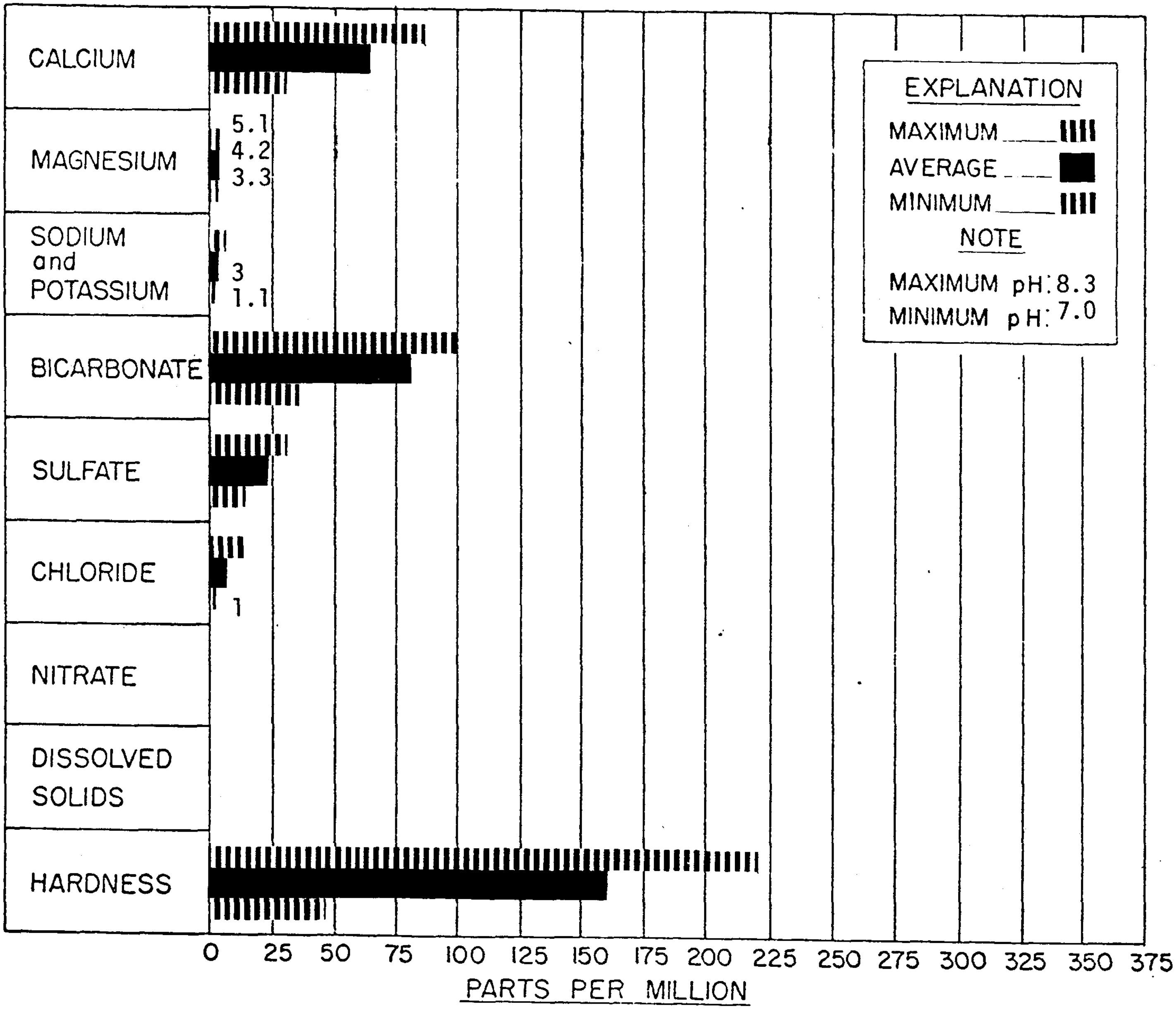
C. Trace Chemical Water Quality

Trace elements are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace Chemicals measured in the two basins are within Kentucky-Federal Water Quality Standards.

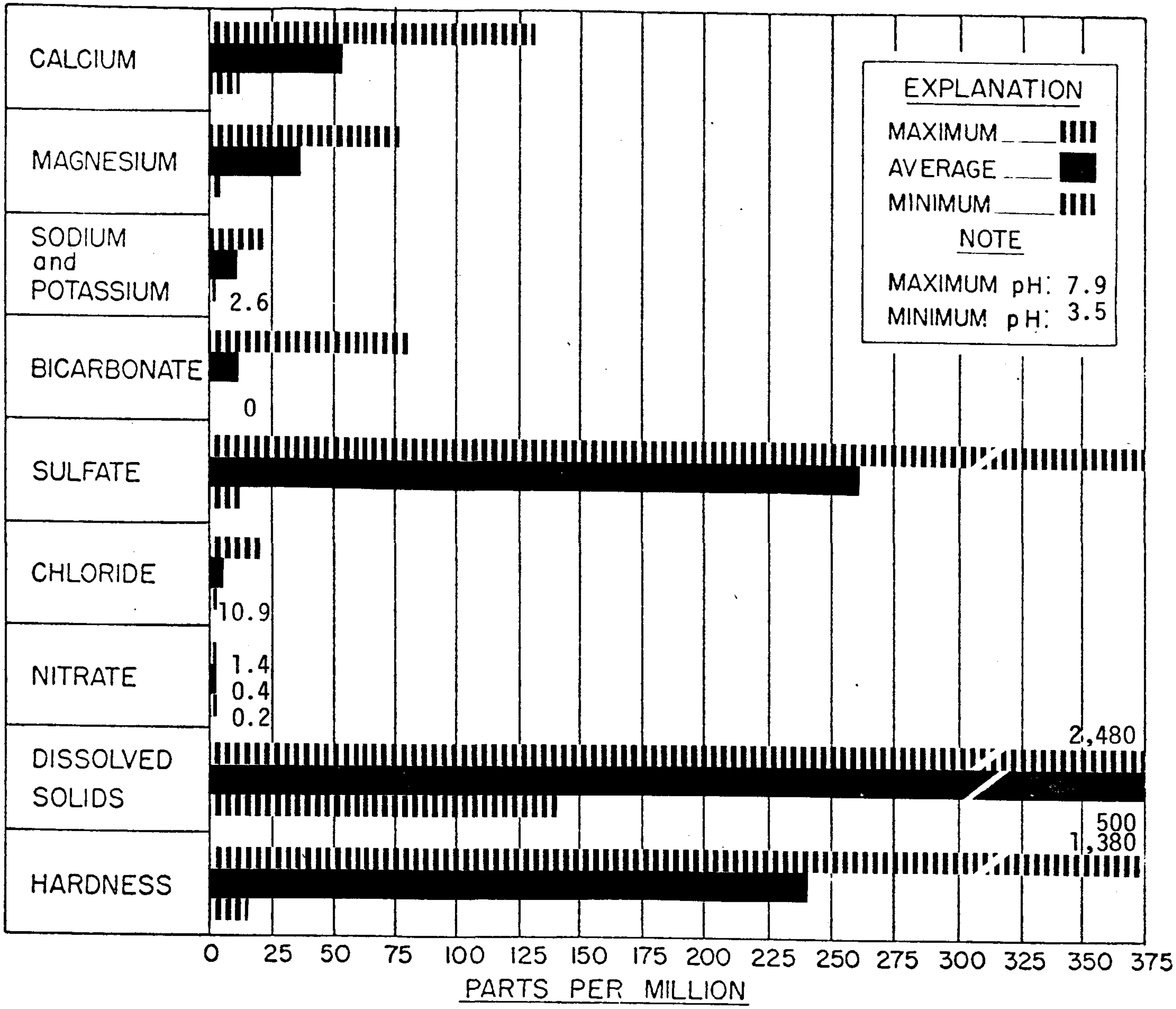
D. Waste Load Effect on Water Quality
(Tradewater and Little Sandy Rivers and Tygarts Creek)

Waste loads are considered to have an effect on water quality when they cause the dissolved oxygen concentration (D.O.) of the water to drop below the Kentucky Water Quality Standard of 5.0 milligrams per liter (mg/l).



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Tygarts Creek near Greenup

Figure B-1



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Trade Water River at Olney

Period of Record 2-59 to 9-73

FIGURE B-2

Approximately 430 miles of stream length were studied under a model developed in the Kentucky Continuing Planning Process for River Basin Management Planning, used to determine waste load allocation. Using this model it was determined that 85 miles of that length would have a D.O. concentration of less than 5.0 mg/l when the flow is equal or less than the 10 year 7 day low flow. Of the stream length affected, four miles (.5 per cent) are by industrial discharge and 56 miles (43 per cent) are affected by municipal discharge. The remaining 45 miles (53 per cent) are affected by discharge from places such as schools, trailer parks, and subdivisions, etc.

E. Non-Point Source Effects Ohio River Kentucky Portion

Major non-point source pollutants of the basin's streams are sediment, agricultural pesticides, solid waste, and animal waste.

Excessive sediment is a result of erosion on surface mined areas, agricultural lands, forest lands, roadbanks, streambanks, construction, and developing areas.

Major erosion sources are summarized as follows:

1. Approximately 452 square miles of the basin's cropland have average erosion rates in excess of acceptable limits.

2. Much erosion is from about 531 square miles of disturbed forest lands. This comprises about 63 per cent of the erosion from forest lands while including about 20 per cent of the total forest lands.

3. An estimated 125 square miles of land in the basin are affected by gully erosion.

4. An estimated 3 square miles per year are being disturbed for industrial and urban expansion.

F. Water Uses

Water use in the minor tributaries from either surface or groundwater is limited since only eight small cities use water from these minor tributaries. There are, also, limited water uses for industrial purposes.

G. Water Quality Changes

The only area where water quality changes are expected in the minor tributaries of the Ohio River are in the Tradewater River Basin and the area of Union County where extensive coal resources exist. This change is anticipated due to the increased demand for coal. Some water quality change will result in the upgrading of waste treatment facilities.

III. Water Quality Causes and Corrections in the Tradewater and Little Sandy Rivers and Tygarts Creek

In the Little Sandy River and Tygarts Creek, the main problems are siltation and organic waste loads. Siltation is mainly from erosion and runoff due to improper agricultural and timbering practices. With the increase in interest for modern farming methods this problem should decrease. The organic waste loads, due to lack of proper treatment facilities, can be alleviated by upgrading treatment methods.

The main problem in the Tradewater River is acid mine drainage and siltation from the coal mining industry. This siltation is the result of two practices, strip mining which causes upheaval of the surface land, and logging which can result in high runoff rates and serious erosion. With the increase in demand for coal due to the energy crisis, great care and vigilance will need to be exercised to see that this problem does not increase.

TABLE B-1

TOTAL DRAINAGE AREA OF OHIO RIVER BASIN IN KENTUCKY
(Excluding the following rivers: Kentucky, Salt,
Green, Big Sandy, Licking, Cumberland and Tennessee

STREAM	DRAINAGE AREA (square miles)
Ohio River:	
Ohio River	6090
Tradewater River	940
Little Sandy River	720
Tygarts Creek	340
Kinniconik Creek	250

TABLE B-2

SLOPE CHARACTERISTICS OF THE LITTLE SANDY AND TRADEWATER RIVERS AND TYGARTS CREEK

STREAM	Average slope (ft./mi.)	Slope in lower 20 miles (ft./mi.)	Slope in lower 70 miles (ft./mi.)
Little Sandy River	8.3		1.7
A. East Fork	11.9	2.6	
B. Little Fork	15.2	3.5	
Tygarts Creek	6.9		3.3
Tradewater River	1.3		0.7

TABLE B-4

Population of the Ohio River Basin in Kentucky

County	Population in 1970 **	Population in basin *
Ballard	28,677	23,400
Boone	32,812	32,650
Boyd	52,376	43,600
Bracken	7,227	4,850
Breckinridge	14,789	10,200
Caldwell	13,179	3,600
Campbell	88,561	79,000
Carroll	8,523	1,600
Carter	19,850	19,850
Christian	56,224	5,400
Crittenden	8,493	7,300
Daviess	79,486	55,500
Elliott	5,933	5,700
Gallatin	4,134	4,134
Greenup	33,192	33,192
Hancock	7,080	6,400
Hardin	78,421	32,600
Henderson	36,031	32,600
Henry	10,910	3,350
Hopkins	38,167	10,200
Jefferson	695,055	371,700
Kenton	129,440	80,500
Lawrence	10,726	760
Lewis	12,355	11,450
Livingston	7,596	2,970
Mason	17,273	10,300
McCracken	58,281	41,800
Meade	18,796	18,696
Oldham	14,687	8,900
Pendleton	9,949	600
Rowan	17,010	1,000
Trimble	5,349	3,500
Union	15,882	15,882
Webster	13,282	9,700
	Total	992,990*

* Approximate measurement ± 10 per cent based on U.S. Census Data

** U. S. Census Data

TABLE B-5

City Population and Facility Grant Status
in the Ohio River Basin in Kentucky

County	Population	Project type	Comments
Ballard			
Boone			
Petersburg	430	None	No Sewers
Boyd			
Ashland	29,200	I	Pending
Bracken			
Augusta	1,434	1	
Germantown	332	None	No Sewers
Breckinridge			
Cloverport	1,388	3	
Hardinsburg	1,547	1	Pending
Irvington	1,300	1	
Caldwell			
Campbell			
Carroll			
Ghent	381	None	No Sewers
Carter			
Grayson	2,184	1	
Olive Hill	1,197	1	Pending
Christian			
Crittenden			
Daviess			
Owensboro	51,400	3	
Elliott			
Gallatin			
Warsaw	1,232	1	Pending
Greenup			
Bellefonte	966	None	No Sewers
Hancock			
Hawesville	1,262	1	Pending
Lewisport	1,595	1	Pending

County	Population	Project type	Comments
Hardin			
Vine Grove	2,987	1	Pending
Henderson			
Corydon	880	None	No Sewers
Campbellsburg	479	3	
Henderson	23,100	3	
New Castle	755	1	
Pleasureville	747	1	Pending
Hopkins			
Dawson Springs	3,009	1	Pending
Hanson	378	None	No Sewers
Mortons Gap	1,169	None	No Sewers
St. Charles	373	None	No Sewers
Jefferson			
Barbourmeade	884	None	No Sewers
Bellemeade	576	None	No Sewers
Brownsboro Farm	823	None	No Sewers
Devondale	1,071	None	No Sewers
Indian Hills	600	None	No Sewers
Keeneland	587	None	No Sewers
Lake Louisvilla	430	None	No Sewers
Moorland	705	None	No Sewers
Kenton			
Lakeview	478	None	No Sewers
Taylor Mill	3,194	None	No Sewers
Lawrence			
Lewis			
Livingston			
Mason			
Maysville	7,200	3	
Washington	439	1	
McCracken			
Paducah	31,200	3	
Meade			
Brandenburg	1,637	3	
Oldham			
Pendleton			
Rowan			
Trimble			
Bedford	780	1	Pending
Milton	756	1	Pending

County	Population	Project type	Comments
Union			
Morganfield	3,563	1	Pending
Sturgis	2,210	1	Pending
Uniontown	1,255	3	
Webster			
Clay	1,426	3	
Dixon	572	None	No Sewers
Jefferson			
Anchorage	1,777	None	No Sewers
Graymoor	1,419	None	No Sewers
Louisville	358,000		Construction
Windy Hills	1,692	None	No Sewers

NOTE: Project type is related to tye type of grant applied for or received by each city. Type I is for preliminary studies necessary before design of the facility. Type 2 is the design phase of a facility and Type 3 is for the construction of a facility for the collection and treatment of domestic sewage.

The comments relate to the status of the grant. Underway indicates the project type is funded. Pending indicates that application for a grant has been made and is pending approval and no sewers means when a grant is requested that it is for a complete and original system.

The source of this information was the 1970 U.S. Census and the FY 75 construction grants list for Kentucky.

TABLE B-6

Water Quality Data in the Ohio River Basin
Data Presented was Collected on Tygarts Creek at Greenup, Kentucky

Parameter	#Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
pH specific units, Kentucky Standard (Ky. Std.) 6 to 9							
	6	7.1	.49	8.3	7.0	4/60	9/72
Conductivity micro mhos, Ky. Std. 800 micro mhos max.							
	9	210	61	300	100	4/60	6/74
Alkalinity mg/l							
	5	81	28	100	35	4/60	9/72
Hardness mg/l, 0-60 soft, 61-120 moderately hard, 121-180 hard, over 180 very hard							
	15	160	53	220	47	4/60	6/74
Sodium mg/l, No Standard							
	10	1.7	1.8	4.9	.30	4/60	6/74
Potassium mg/l, No Standard							
	10	1.3	.38	1.9	.8	4/60	6/74
Chlorine mg/l							
	6	6	4	13	1	4/60	9/72
Sulfate mg/l, Proposed E.P.A. Standard 250 mg/l							
	5	23	5.6	31	14	4/60	9/72
Calcium mg/l, No Standard							
	10	66	15	82	30	4/60	6/74
Manganese mg/l							
	9	150	360	1100	17	6/74	6/74
Magnesium mg/l, No Standard							
	10	4.2	.51	5.1	3.3	4/60	6/74

TABLE B-7

Water Quality Data in the Ohio River Basin
Data Presented was Collected on Tradewater River at Olney, Kentucky

Parameter	#Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
pH specific units, Kentucky Standard (Ky. Std.) 6 to 9							
	386	5.9	1.1	7.9	3.5	12/59	09/73
	18	6.5	0.9	7.9	5.0	01/73	09/73
Conductivity micro mhos, Ky. Std. 800 micro mhos max.							
	419	500	340	2480	50	10/59	09/73
	18	520	330	1070	130	01/73	09/73
Dissolved Solids Milligrams per liter (mg/l), Ky. Std. 500 micro mhos							
	13	500	260	1060	140	02/60	11/72
Alkalinity mg/l, No Standard							
	193	11	12	80	0	12/59	09/73
	18	13	8	26	2	01/73	09/73
Hardness mg/l, 0-60 soft, 61-120 moderately hard, 121-180 hard, over 180 very hard							
	385	240	180	1380	15	10/59	09/73
	18	270	190	610	53	01/73	09/73
Color Platinum Cobalt Units, Prop. E.P.A. Std. 75 Units							
	132	8.4	12	100	0.0	12/59	10/72
Sodium mg/l, No Standard							
	22	7.9	3.6	15	2	12/59	11/72
Potassium mg/l, No Standard							
	22	2.5	1.5	5.2	0.6	12/59	11/72
Chloride mg/l, Proposed E.P.A. Standard 250 mg/l							
	270	4.5	2.7	21	0.9	12/59	09/73
	18	3.2	0.87	5	1.5	01/73	09/73
Sulfate mg/l, Prop. E.P.A. Std. 250 mg/l							
	270	260	240	1600	12	12/59	09/73
	18	240	180	570	35	02/73	09/73
Nitrate mg/l, N mg/l, Prop. E.P. A. Std. 10 mg/l							
	36	0.4	0.2	1.4	0.2	04/72	09/73
	18	0.4	0.1	0.5	0.2	01/73	09/73
Flouride mg/l, Kentucky Standard 1.0 mg/l							
	51	0.3	0.3	0.9	0.1	05/70	11/74
	19	0.4	0.3	0.9	0.1	01/73	11/74

Parameter	#Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
Calcium mg/l, No Standard							
	22	52	29	130	11	12/59	11/72
Magnesium mg/l, No Standard							
	22	35.6	19.6	76	4.2	12/59	11/72
Cadimum micrograms/liter, Ky. Std. 100 ug/l							
	48	2.3	2.1	12	0.0	08/70	11/74
	18	2.1	1.7	8	0.0	01/73	11/74
Manganese, micrograms/liter, Prop. Ky. Std. 50 ug/l							
	154	4212	5625	33,000	0.0	10/65	09/73
	18	1886	3085	12,000	0.0	01/73	09/73
Iron, micrograms/ liter, Prop. E.P.A. Std. 300 ug/l							
	156	92	256	2,600	0.0	10/65	09/73
	18	46	63	180	0.0	01/73	09/73
Chromium, micrograms/liter, Ky. Std. 50 ug/l							
	51	1.2		4	0	05/70	11/74
	18	1.6	1	3	0	01/73	11/74
Lead, micrograms / liter, Ky. Std. 50 ug/l							
	47	10.8	6.0	28	1	05/70	11/74
	19	11.3	5.2	21	4	01/73	11/74
Silver, micrograms/liter, Ky. Std. 50 ug/l							
	51	1.0	1.0	6	0		
	19	1.2	0.7	3	0	01/73	11/74
Arsenic, micrograms/liter, Ky. Std. 50 ug/l							
	13	0.4	0.5	1	0		04/74

#Obs: Total number of observations in period shown

TABLE B-8

Water Withdrawal - Ohio River Basin

	Source	SW*	GW**	(Million Gallons/Day) Public	Industrial
Boyd					
Ashland Mun. Water Works	Ohio River	x		3.442	1.475
Breckinridge					
Hardinsburg Mun. W. W.	Hardins Ck. Reservoir	x		.124	.001
Campbell					
Newport Municipal W. W.	Ohio River	x		5.065	.894
Carter					
Grayson Utility Comm.	Little Sandy	x		.282	
Olive Hill Mun. W. W.	Reservoir on Perry Branch	x		.166	.002
Carter Caves State Park	Tygarts Creek	x		.032	
Crittenden					
Marion Municipal W. W.	Reservoir	x		.264	.088
Greenup					
Greenbo Lake State Park	Greenbo Lake	x		.008	
Russell - C & O Railroad	Ohio River Wells (3)	x	x		.100 GW .900 GW
Wurtland - E.I. Dupont DeNemours Co.	Ohio River Wells (2)	x	x		.034 GW 5.400 SW
Hardin					
Ft. Knox	Otter Creek 12 wells	x	x	4.711 GW 2.385 SW	.523 GW .265 SW
Vine Grove	Otter Creek & Brushy Fk.	x		.233	
Henderson					
Henderson Municipal W. W.	Ohio River	x		3.090	.421
Henderson Farmers Tankage	Ohio River	x			.421
Jefferson					
Louisville Water Co.	Ohio River	x		62.290	52.271
Airco Alloys & Carbide	Ohio River & 6 wells	x	x		2.100 GW 8.000 SW
E.I. Dupont DeNemours Co.	Ohio River & 10 wells	x	x		5.641 GW 68.515 SW

	Source	SW*	GW**	(Million Gallons/Day) Public	Industrial
Kenton					
Covington Municipal W. W.	Ohio River	x		5.800	1.800
McCracken					
Paducah Municipal W. W.	Ohio River	x		4.641	.819
Shawnee Steam Plant	Ohio River	x		.028	1.581
Mason					
Maysville Utility Comm.	Ohio River	x		.748	.499
Meade					
Otter Creek Park	Otter Creek	x		.047	
Oldham					
LaGrange Municipal W. W.	Brush Creek Reservoir	x		.479	.084
Union					
Morganfield Water Works	Ohio River	x		.650	
Hamilton Mine	Ohio River				.031
DeKovin Mine	Denis O'Nan Reservoir and well	x	x		.030 GW .170 SW
Uniontown Municipal W. W.	Ohio River	x		.102	.005
			Total SW	92.261	143.642
			Total GW	4.711	8.394

*Surface water
**Ground water

TABLE B-9

Organic Loads Affecting Streams in the Ohio River Basin

Length of streams to which treated organic loads are discharged		431 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		85 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	36 miles
	Industrial Discharges	4 miles
	Other Discharges	45 miles

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year, seven day, low flow.

THE TENNESSEE RIVER BASIN

The Kentucky portion of the Tennessee River basin makes up the Eastern half of an area in the far western corner of the state called the Jackson Purchase region (named after General Andrew Jackson who, in 1818, arranged the purchase treaty with the Chickasaw Indians). The Jackson Purchase region is unique in many respects from the rest of Kentucky. This report will discuss first the Tennessee River basin in general in this region of Kentucky, and secondly discuss existing water quality in the area and the factors that influence water quality in the basin.

I. Basin Description

A. Geography

The Tennessee River joins the Ohio River near Paducah, Kentucky, at mile point 46.9 of the Ohio. The Tennessee River crosses the Kentucky-Tennessee border at mile point 51.1 and continues along the border to mile point 62.3, where it leaves Kentucky.

The basin encompasses all or portions of the following counties in Kentucky: Calloway, Graves, Livingston, Lyon, Marshall, McCracken, and Trigg. Of the total drainage area for the river of 40,330 sq. mi., approximately 1,000 sq. mi. are in Kentucky. (See Table I) The one major tributary to the Tennessee River in Kentucky is the Clarks River, which has a total drainage area of 530 sq. mi. The remaining area drains directly into the Tennessee River.

B. Topography

Low hills comprise the headwater areas which become rolling hills, then abruptly change in a flood plain as it nears the main stem. Elevations vary from

300 to 620 feet above sea level, with an average slope in the East Fork of Clark's River of 4.6 ft./mi., and 7.0 ft./mi. in the West Fork. The main stem of the Tennessee River to mile point 22 is within the influence of the Lock and Dam 52 on the Ohio with a pool elevation of 302. At mile point 22 Kentucky Dam forms Kentucky Lake and the pool extends into Tennessee to the Pickwick Landing Dam.

C. Geology

The geology of the area is made up of 4 major types of formations, all of which are primarily sand and clay mixtures, with gravel and silt in varying amounts. The bedrock of the area consists of limestone, chert, and dolomite.

The sand and clay formations are generally sources of good quality groundwater. Groundwater from the bedrock is often high in iron content, and can be treated if necessary before use. Generally, the groundwater quality is consistently good and may yield as much as 1,700 gallons per minute (g.p.m.). For these reasons it is a valuable source of domestic and industrial water supply in the basin.

D. Hydrology

The Tennessee River itself is a highly developed river system, with a series of locks and dams from near the mouth to the upper headwaters. Also, for navigation and for better flow regulation a canal was built between Lake Barkley and Kentucky Lake. The impoundment of the Tennessee River has resulted in superb regulation and increased the minimum daily flow from 5000 cfs to in excess of 20,000 cfs.

Flow in the Clarks River is not regulated or augmented by dams and reservoirs.

Flow measurements have been taken on the main stem of the Tennessee River and on both the East and West Forks of Clark's River. These recorded flows are:

Flow Record Summary

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 day 10 yr. Low Flow
Tennessee River near Paducah	8 yr.	40,200 sq. mi.	62,180 cfs, 1.55 cfs* / sq. mi.	359,000 cfs, 8.93 cfs / sq. mi.	23,900 cfs, .59 cfs / sq. mi.	712.9 cfs
East Fork Clarks River near Benton	35 yr.	227 sq. mi.	278 cfs, 1.22 cfs / sq. mi.	36,000 cfs, 158.6 cfs / sq. mi.	1.8 cfs, .01 cfs / sq. mi.	2.2 cfs
West Fork Clarks River near Brewers	5 yr.	68.7 sq. mi.	84.7 cfs, 1.23 cfs / sq. mi.	7,060 cfs, 102.7 cfs / sq. mi.	1.2 cfs, .02 cfs / sq. mi.	0.8 cfs

*Cubic Feet Per Second

Note: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

Periodically, flow on the main stem of the Tennessee River below Kentucky Dam goes to zero due to maintenance and operation of the turbines for hydroelectric power generation. These flow outages do not exceed 7 days, and impounding provisions for waste discharges are provided to accommodate this flow outage.

Kentucky Lake is the only lake of note in the Tennessee River basin in Kentucky. It is a multi-purpose reservoir, for flow augmentation, flood control, hydroelectric power production, and recreation. Its maximum capacity is 7,415,000 acre feet, covering an average area of 306,000 acres. ? flood capacity

E. Population

The total population in the Tennessee River basin in Kentucky is 68,412. Murray, Kentucky, in Calloway County, with a population of 13,700 is the largest city in the area. Seven smaller communities make up the rest of the urban population which totals 25,277. This represents 37 per cent of the total population. The remainder of the population is located in rural areas. The urban distribution is shown in Table C-3.

Population in a basin is an important factor in the water quality of the basin, as water is used for a great variety of purposes, then discharges back into the streams. Influence of waste discharges are discussed in the second part of this report.

II. Basin Water Quality

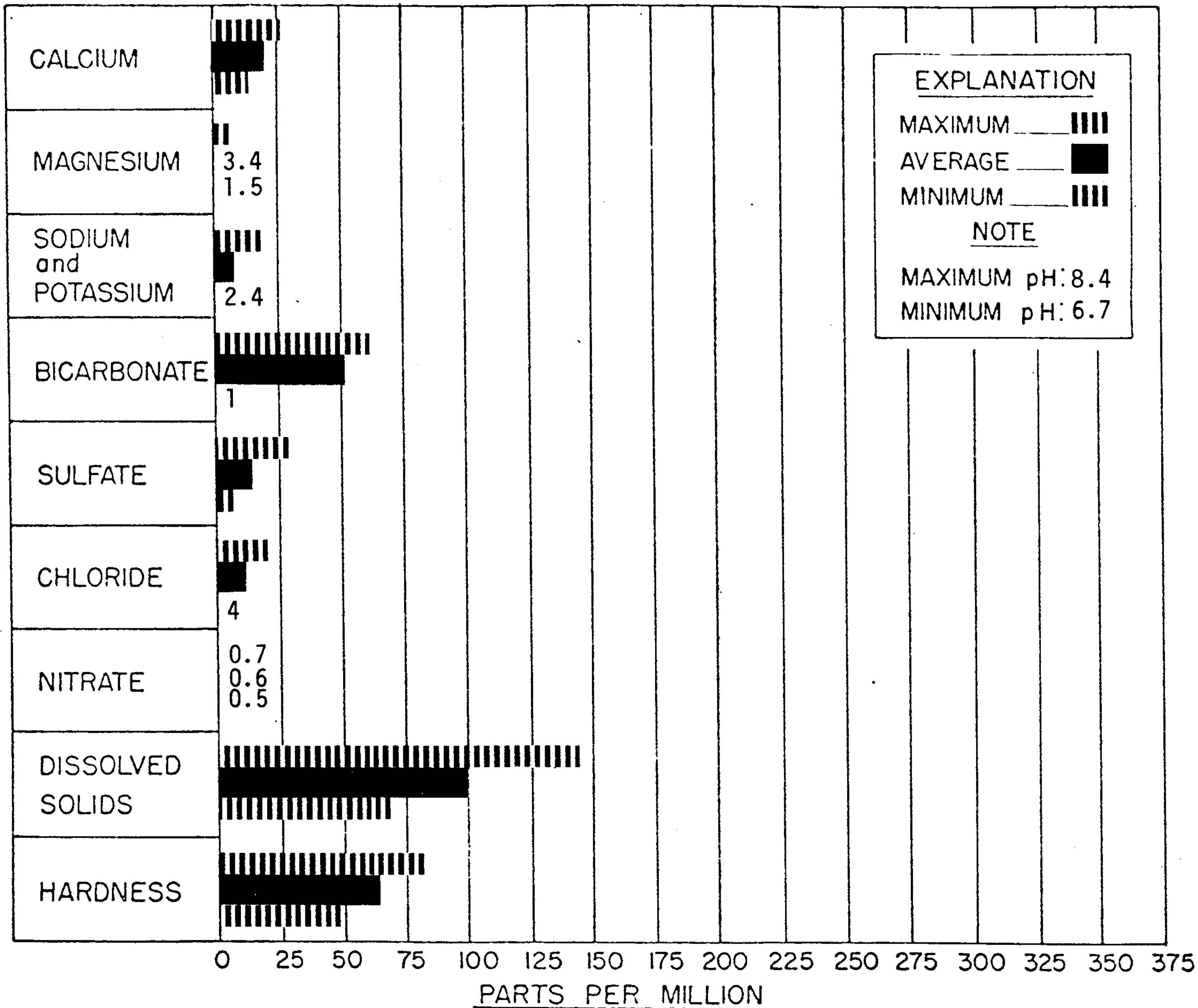
A. Description of Sampling Stations

Samples of the water, for testing its quality, were taken at a U.S.G.S. flow gauging station on the Tennessee River near Paducah, Kentucky. This is located in the far northern portion of the basin. Drainage area above the station is 40,200 sq. mi., representing almost the entire drainage area in the Tennessee River basin. Data obtained from this sampling and testing is listed in Table A-4 and Figure A-1.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

In the main stem of the Tennessee River in Kentucky, the quality of the water is excellent. The impoundment of the water by Kentucky Dam has shown a marked stabilization effect on water quality values (little variation between maximum and minimum). This consistency of water quality is significant in that when water quality is stable, standards for effluent discharged into that water may be well defined, and more confidence can be placed in monitoring results. Insufficient data was available to reach a conclusion concerning the water quality of Clarks River.



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Tennessee River at Paducah

Period of Record: 10-59 to 11-74

FIGURE C-1

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the main stem of the Tennessee River in Kentucky were measured as being within Kentucky/Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemical degradable waste impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 248.0 miles of streams in the basin that receive waste discharges were evaluated. Based upon present treatment levels and once in 10 year 7 day low flows, the model indicated that in 59.0 miles of stream the D.O. concentration is below 5.0 mg/l. Fifteen of the 59.0 miles of streams are affected by a municipal discharge, 10.5 by industrial, and 33.5 miles by various other discharges (subdivisions, mobile home parks, small businesses, etc.). These distances represent 6 per cent, 4 per cent, and 14 per cent, respectively, of the total stream miles in the basin which have a discharge. (Table A-5)

E. Non-point Source Effects

Non-point pollution is a problem in Kentucky's portion of the Tennessee River basin. The major non-point sources of pollution in the basin are summarized below:

1. Land Use: Soil erosion from 145.0 sq. mi. (15% of basin area) of farm land is considered excessive by VIDA-SCS. Logging operations, burning, and grazing in 44 sq. mi. (5% of basin area) of forest land has resulted in severe soil erosion in the area.

2. Animal Wastes: All agricultural feedlots in Kentucky have a capacity of less than 1,000 animal units and no NPDES permits have been issued in Kentucky for feedlots. Kentucky has developed a manure lagoon disposal system in cooperation with the USDA-SCS which is currently under study and is used by some small feedlots. These lagoon systems have been employed in the Mississippi River Basin and protected water quality when properly operated.

3. Urban Run-off: Surface runoff from the city of Murray can have an effect on stream water quality. Without data on the effect, which is probably rather minor, the quanitation will need special investigation as part of water quality management.

F. Water Uses

Surface and ground waters in the Tennessee River Basin in Kentucky are used for Public, Industrial, Fish and Wildlife, Recreation, and Agricultural Water Supply. The groundwater in this area is generally of good quality with the exception of iron. Groundwater is the source of about 90 per cent of the public water supply in the region amounting to 2.0 million gallons per day (m.g.d.).

Due to the industrial location groundwater does not play an important role for industrial water supply. The industrial use of groundwater in the basin is 3 m.g.d. Of the 45.0 m.g.d. used in the basin for industrial purposes, about 42.0 m.g.d. (93 per cent) is supplied by the main stem of the Tennessee River.

Kentucky Lake and Barkley Lake with the Land Between the Lakes serves as a recreational area of great diversity. The water quality supports game fish, plants, and wildlife and the size of the area accommodate a large number of people. Millions of people use Kentucky Lake for various recreational activities, and the Tennessee River is valuable for commercial fishing and mussel shells.

Water in the basin is used in the agricultural industry primarily for livestock watering with a small amount used for irrigation. There is no known area in the basin where water is restricted from use for agricultural needs.

G. Water Quality Changes

The potential for water quality changes particularly within a mixing zone occurs as a result of large scale industrial development located at Calvert City. Particular attention must be paid to compliance monitoring and special services to prevent any water quality deterioration from this complex. Of the water quality changes which can be expected are for the better as waste treatment facilities are upgraded to maintain dissolved oxygen levels above 5 mg/l. Because of the high level of recreation use of Kentucky Lake particular attention must be paid to probable waste disposal at camp sites, recreation developments, State parks, and other facilities to provide spot contamination of the lake. This control is being exercised by revising of plans and specifications for water disposal systems and the further restrictions imposed in the location of septic tanks and drain fields in relationship to the elevation of Kentucky Lake.

III. Summary

The water quality in the main stem of the Tennessee River in Kentucky is excellent. Sampling and testing in the Clarks River basin have not been sufficient to make a definite conclusion as to the water quality throughout the basin. To maintain the high water quality in the basin requires attention of industrial waste effects at Calvert City and upgrading of the municipal sewage treatment plant.

Treated wastes discharged from municipal, independent, and industrial sources effect the quality of the basin's streams. The need to upgrade or eliminate waste sources is being determined in the basin planning process. Another aspect of this problem is the need for improved operation and maintenance of waste treatment facilities through a program of operator licensing and education. Kentucky has instituted such programs.

Table C-1
Population in the Tennessee River Basin by County

County	Area (sq. mi.)	1970 Pop.	Area in Basin (sq. mi.)	Pop. in Basin
Calloway	384	27,692	367	27,082
Graves	560	30,939	102	3,494
Livingston	311	7,596	39	868
Lyon	216	5,562	35	509
Marshall	303	20,381	303	20,381
McCracken	249	58,281	48	15,000 est.
Trigg	408	8,620	74	1,078
			968	68,412

Note: The information in this table was taken from the 1970 Census as reported in the Rand McNally.

Table C-2

Water Withdrawal in the Tennessee River Basin

County-City-Withdrawer	River/Lake	SW	GW	Public (mgd)	Industrial (mgd)
Calloway					
Dexter-Almo Hts. W. Dist.			x	.023	
Hamlin-G. H. Wesson			x		.146
Hazel Mncp. W. W.			x	.022	
Lynn Grove Mncp. W. W.			x	.004	
Murray Mncp. W. W.			x	1.0	.73
Lynhurst Resort, Inc.			x	.026	
Murray Bait Co.			x		.24
Murray State U.			x		.69
Graves					
Symsonia W. Dist.			x	.025	.001
Livingston					
Grand Rivers Mncp. W. W.	Ky. Lake	x		.06	
Lake City W. Dist.	Ky. Lake	x		.032	
McCracken					
Reidland W. Dist			x	.15	.008
Marshall					
Benton Mncp. Water and Sewer System			x	.32	.007
N. Marshall Co W. Dist.			x	.19	.021
Jonathan Creek Water Ass.	Ky. Lake	x		.14	
Calvert City Mncp. W. W.			x	.45	
Airco Alloys and Carbide	Tenn. R.	x			12.0
American Aniline & Extract			x		.19
B. F. Goodrich Chem. Co.	Tenn. R.	x			4.0
GAF Corp.			x		1.3
Pennwalt Chem. Corp.	Tenn. R.	x			25.0
Pittsburg Metallurgical	Tenn. R.	x			1.3
Gilbertsville Mncp. W. W.			x	.03	
Hardin Mncp. W. W.			x	.05	
Ky. Dam Village S. P.			x	.19	
Ky. Lake S. P.			x	.068	

*Mncp. W. W. - Municipal Water Works
W. Dist. - Water District
S. P. - State Park

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table C-3

Population Distribution in the Tennessee River Basin

County - City	Population	Federal Assistance	Comments
Calloway			
Murray	13,700	I	Pending
Hazel	424	none	Sewered
Graves			
Symsonia	500	I	Pending
Livingston			
No Major Population Center in the Basin			
Lyon			
No Major Population Center in the Basin			
McCracken			
San. Dist. # 2	3,500	III	Underway
Reidland	875	none	Sewered
Marshall			
Benton	3,652	III	Underway
Calvert City	2,104	I	Pending
Hardin	522	none	Sewered
	25,277		
Trigg			
No Major Population Center in the Basin			

*These are all of the cities with a population greater than 300.

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality.

Table C-4

Water Quality Data in the Tennessee River Basin
Data Presented was Collected in the Tennessee River near Paducah, Kentucky

Parameter	# Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
pH specific units, Kentucky Standard (Ky. Std.) 6 to 9							
	35	7.4	.4	8.4	6.7	10-59	08-72
Conductivity micro mhos, Ky. Std. 800 micro mhos max.							
	66	170	27	225	116	10-59	08-72
Residue milligrams per liter (mg/l), Ky. Std. 500 mg/l max.							
	58	100	17	145	68	10-59	08-72
Alkalinity mg/l, No Standard							
	28	51	11	62	1	10-59	08-72
Hardness mg/l, 0-60 soft, 61-120 moderately hard, 121-180 hard, over 180 very hard							
	55	65	8	82	50	10-59	08-72
Color units, Proposed E.P.A. Standard 75 units max.							
	42	9	13	60	2	10-59	11-70
Sodium mg/l, No Standard							
	41	6	2.4	11	1.9	10-59	11-70
Potassium mg/l, No Standard							
	35	1.2	1.2	8	.5	10-59	11-70
Chloride mg/l, Proposed E.P.A. Standard 250 mg/l							
	58	11	4.7	20	4	10-59	08-72
Sulfate mg/l, Proposed E.P.A. Standard 250 mg/l							
	58	13	3.6	28	6.2	10-59	08-72
Nitrate mg/l, Proposed E.P.A. Standard 10 mg/l							
	2	.6	.1	.7	.5	03-72	08-72
Fluoride mg/l, Kentucky Standard 1.0 mg/l							
	55	.3	.2	.9	.1	03-70	11-74
Calcium mg/l, No Standard							
	41	20	3	26	15	10-59	11-70
Magnesium mg/l, No Standard							
	41	3.4	.9	5.2	1.5	10-59	11-70
Cadmium micrograms per liter (ug/l), Kentucky Standard 100 ug/l							
	55	1	2.4	14	0	02-70	11-74

Table C-4
Page 2

Parameter	# Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
Chromium ug/l, Proposed E.P.A. Standard 50 ug/l							
	55	3.3	10.4	77	0	02-70	11-74
Lead ug/l, Kentucky Standard 50 ug/l							
	51	26	51	283	1	02-70	11-74
Silver ug/l, Kentucky Standard 50 ug/l							
	55	3	8.7	43	0	02-70	11-74
Arsenic ug/l, Kentucky Standard 50 ug/l							
	14	.6	.8	3	0	10-70	08-74

Table C-5

Organic Loads Affecting Streams in the Tennessee River Basin

Length of streams to which treated organic loads are discharged		248.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		59.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	15.0
	Industrial Discharges	10.5
	Other Discharges	33.5

Note: This information is from the wasteload allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q10-7) low flow.

LOWER CUMBERLAND BASIN

The first section of this report will deal with the general description of the basin. The second section will go into a discussion of the water quality in the basin, its causes and effects.

I. Basin Description

A. Geography

The Lower Cumberland River is located in Western Kentucky. The confluence with the Ohio River is at the town of Smithland, Kentucky. The Kentucky-Tennessee border is at mile point 74.7 on the Cumberland River. The area of this portion of the drainage basin in Kentucky is 1,900 sq. mi. of a total drainage basin area of 17,900 sq. mi. This basin contains all or portions of 9 Kentucky counties which are listed in Table D-1. There are two major sub-basins in this region, namely the Little River with 601 sq. mi. and the Red River with a total drainage basin area of 1,460 sq. mi. of which 688 is in Kentucky. At mile point 30.3 Barkley Lock and Dam forms Barkley Lake with a pool of 118 miles in length; 44 miles of which are in Kentucky.

B. Topography

The topography of the Lower Cumberland River Basin is composed of gently rolling plains and "Karst" areas. Karst topography is characterized by sinkholes, underground solution channels and caves.

Stream slopes affect the rate at which dissolved oxygen levels are replenished. Stream slopes of 2 feet per mile and less have low reaeration rates, slopes of 2 feet per mile to 6 feet per mile have moderate reaeration rates, and slopes of 6 feet per mile and greater have higher reaeration rates. The main stem of the Cumberland River below Barkley Lake has a slope of 5.7 feet per mile to the point where Livingston Creek enters the Cumberland River. The slope the is very low from Livingston Creek to the Ohio River. Of the major tributaries listed in Table D-2, three based on slope only have low reaeration rates, five have moderate reaeration rates and fourteen have high reaeration rates. Many of the tributary streams have a low slope near the confluence with the Cumberland River which can present special problems in maintaining dissolved oxygen levels of 5 milligrams 1 liter (mg/l).

In the Lower Cumberland Basin stream elevations in the headwaters rise to 600 feet above mean sea level (m.s.l.). The elevation is 302 feet at the Ohio River.

C. Geology

The principal geological feature of this basin contributing to surface water quality is the limestone parent material. Limestone underlies the entire basin with the exception of the Livingston County portion which is part of a fluoropsar district along the Ohio River. The limestone base parent material contributes to the hardness of the groundwater which ultimately contributes to the hardness of the surface water.

The limestone parent material does not provide high yielding aquifers. Groundwater reserves are moderate to low throughout the basin. In approximately 80 per cent of the basin, wells produce 50 g.p.m. or less and the remaining wells produce 50-500 g.p.m.

D. Hydrology

The Cumberland River is a highly developed river system with a series of locks and dams which permit navigation upstream for 380 miles. The river above this point is further regulated by dams for multiple purpose control, principally flood, recreation and power. There are three lakes in this portion of the basin with surface areas of over 100 acres: Lake Barkley with 57,900 acres, Lake Morris with 170 acres and Lake Boxley with 166 acres. Lake Barkley is regulated for navigation, flood, power, recreation and fish and wildlife purposes. The Kentucky-

Barkley canal at mile point 32.7 permits navigation between Barkley and Kentucky Lake and provides for flow regulator.

The USGS flow gauging stations data at Little River at Cadiz in Trigg County and the Cumberland River at Grand Rivers in Lyon County is tabulated below. The Little River enters Barkley lake 59 miles from the Ohio River and drains an area of 244 sq. mi. The gauging station at Grand Rivers measures the flow through Barkley Lake and drains an area of 17,600 sq. mi. Occasionally the flow from Barkley Dam is stopped for operating and maintenance of the facilities for periods which do not exceed seven days.

Surface Flow Gaging Station Data

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 Day 10 Yr. Low Flow
Little River at Cadiz	34 yr.	244 sq. mi.	337 cfs* 1.38 cfs/sq. mi.	14200 cfs 58.2 cfs/sq. mi.	1 cfs 0 cfs/sq. mi.	0.06 cfs
Cumberland River at Grand Rivers, Kentucky	25 yr.	17,598 sq. mi.	27,510 cfs 1.56 cfs/sq. mi.	201,000 cfs 11.4 cfs/sq. mi.		620 cfs
	9 yr,		37,300 cfs** 2.12 cfs/sq. mi.			

*Cubic Feet Per Second

**Since opening Kentucky-Barkley Canal in 1966

E. Population

The population of the Lower Cumberland Basin in Kentucky is predominately rural. Small communities are located along the main stem and many of the smaller tributaries. The county with the largest population is Christian County with 56,224 persons. The city of Hopkinsville in Christian County has a population of 21,409. The other municipality with a population over 2,000 is Princeton with 6,292 population. The total basin population is 92,380 of which 45 per cent is urban and 55 per cent is rural.

THE LOWER CUMBERLAND RIVER BASIN

II. Basin Water Quality

A. Description of Sampling Stations

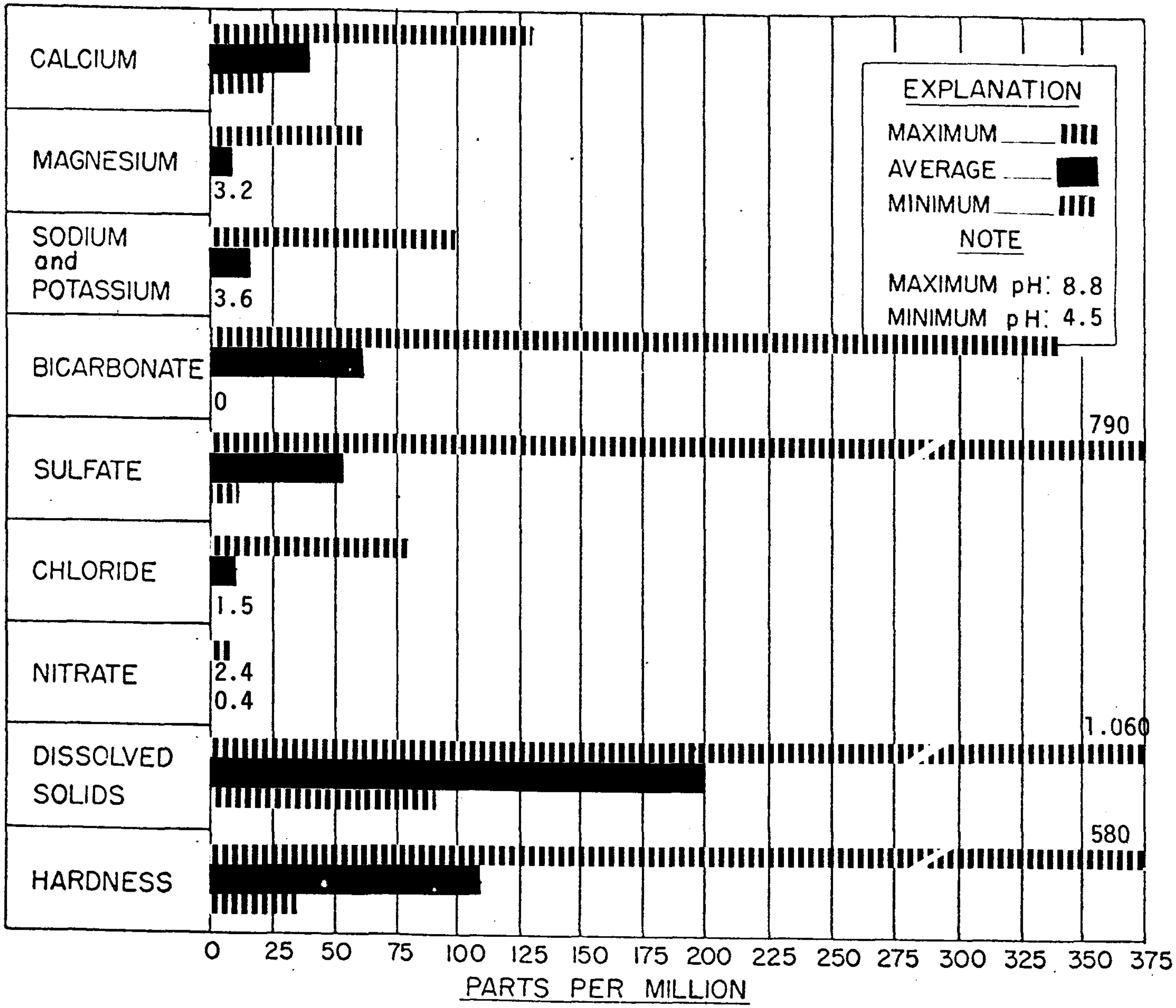
Two sampling stations were chosen to characterize the water quality for the Lower Cumberland River Basin. The USGS gauging station was on the Cumberland River at Grand Rivers below Barkley Lake. The total drainage area above this station 17,598 square miles. The Kentucky Water Quality station used was the Princeton water plant intake on Barkley Lake in Caldwell County.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Two stations were selected to characterize the general chemical water quality in the Lower Cumberland River Basin. The data received from the U.S. E.P.A. STORET system was incorrect. It appeared that the data sent was mixed with values other than those obtained at the Grand Rivers sampling station. The water

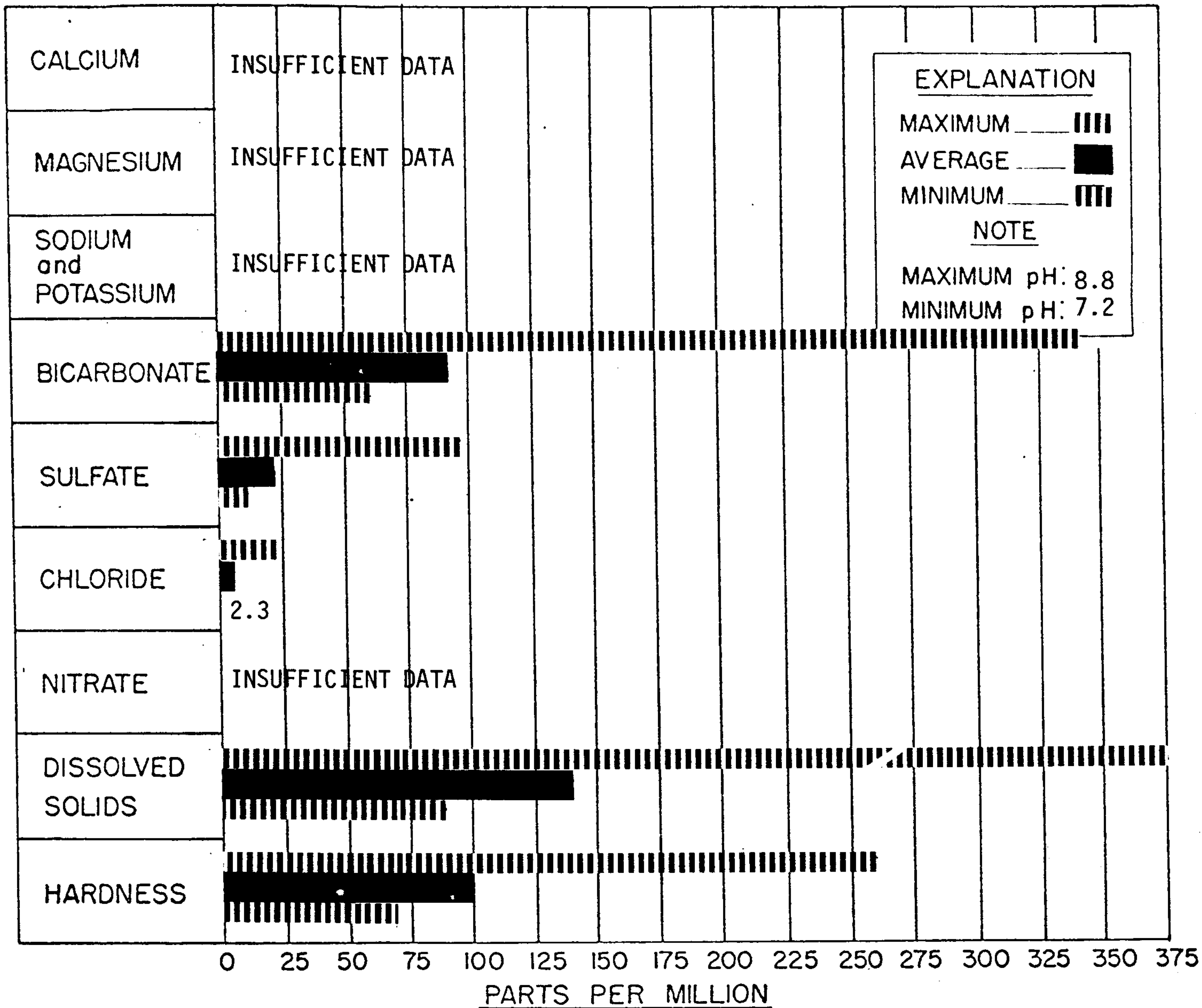
FIGURE D-1



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Lower Cumberland at Grand Rivers

Period of Record: 8-66 to 12-74

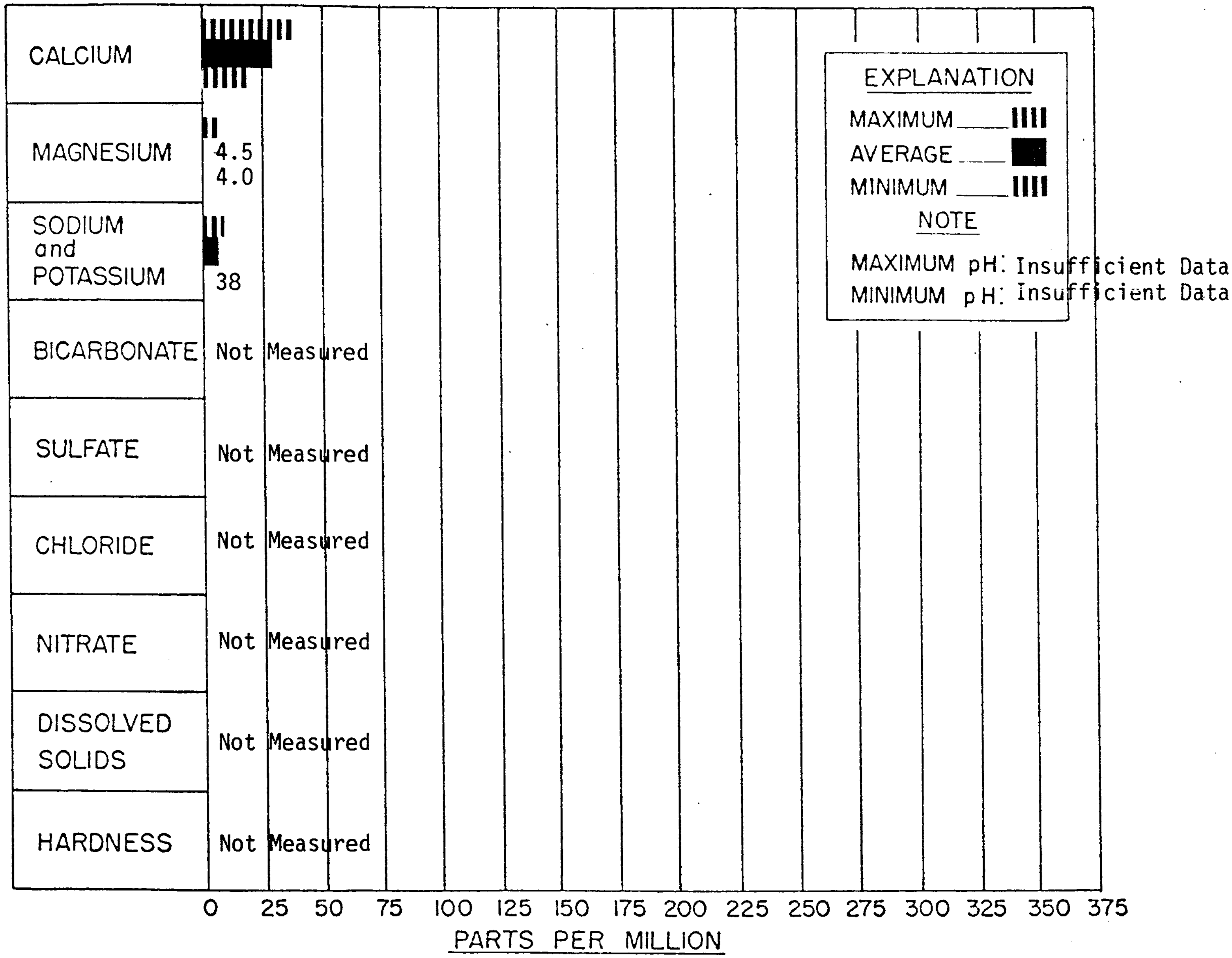


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Lower Cumberland at Grand Rivers

Period of Record: 11-73 to 12-74

FIGURE D-2



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Lower Cumberland at Princeton -

Period of Record 4-73 to 11-74

FIGURE D-3

quality, however, in the Cumberland River Basin should be reflective of the same water quality as the Tennessee River below Kentucky Dam since the canal permits free interchange of water between the two lakes.

C. Trace elements (under 5 mg/l) are separated from the general chemical background of this report because on their influence on human health. Generally, these materials are "heavy" metals which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State and Federal Water Quality Standards.

All trace chemicals measured in the Lower Cumberland Basin with the exception of lead and chronimum were within Kentucky-Federal Water Quality Standards. Average values for all trace chemicals including lead and chronium were within Kentucky-Federal guidelines. The value for lead exceeded the limit one time; the level being .07 mg/l as compared with the standard of .05 mg/l. The value for chronimum is for total chronimum rather that the hexa valent chronimum and the level of exceedence at .11 mg/l is not sufficient to warrent further investigation.

D. Waste Load Affect on Water Quality

Biochemical degradable waste impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an affect on stream quality when they cause the dissolved oxygen (D.O.) levels to drop below Kentucky Water Quality Standards of 5 mg/l.

Using a model developed in conjunction with the River Basin Planning Process, 360 miles of streams with waste loads in the Lower Cumberland Basin were studied. Of this total, 17.3 per cent or 62.2 miles were shown to have loads in 1975 which would cause the D.O. levels to be below 5 mg/l at a low flow occurance of once in 10 years for 7 days.

The type of waste and the distance affected in this basin where D.O. levels are less than 5 mg/l, are municipal discharges 40 miles or 11% of the total industry 2.4 miles or 0.7% and other discharges (hospitals, mobile home parks, and schools) 20 mile or 6%.

E. Non-Point Source Effects

The major non-point pollutants from the portion of Kentucky that drains directly into the Cumberland River are sediment, animal waste, and solid waste.

Sources of excessive sediment areas were identified in an inventory of critically eroding areas prepared in 1974 by the USDA Soil Conservation Service. About 122 square miles (sq. mi.) of cropland were judged to have excessive erosion rates. An estimated 44 sq. mi. of forest land have excessive erosion as a result of logging operations, burning, and grazing.

F. Water Uses in the Basin

Most of the surface water withdrawn in this basin is for public uses. Of the total surface water used, 4.8 million gallons per day were used for municipal purposes. Industrial uses of surface water amounts to gallons per day. A complete breakdown of water uses both surface and groundwater by industries and municipalities is shown in Table D-8.

At the present time, agricultural uses of surface water supplies is primarily livestock watering. It can be expected that use of surface waters for irrigation will increase in the future.

Barkley Lake in the Lower Cumberland River Basin and Kentucky Lake in the Tennessee River Basin provide a great variety of water related activities. Barkley Lake is the largest lake in the Cumberland River system. Lake Barkley State Resort Park at Cadiz, Kentucky and the Land-Between-the-Lakes provides for both water and non-water recreational activities year round.

G. Water Quality Changes

The water quality in the Lower Cumberland River Basin in the main stem and Barkley Lake is of uniform excellent quality. This conclusion is derived from a few values from STORET data which were known to be from the main stem of the Cumberland River and from the information presented in the Tennessee River Basin Report. Both of these rivers are interconnected by canal and, therefore, share similar water quality. As far as tributary streams to the Cumberland River, the changes expected, will be for upgrading for waste treatment facilities with an accompaning improvement for water quality and better control of land use practices particularly agricultural uses to minimize the effects of soil erosion. The Soil Conservation Service has identified a particular area of concern and cooperative efforts of the Division of Water of the Department for Natural Resources and Environmental Protection with the Soil Conservation Service will produce the necessary control to minimize the effect of sedimentation in the tributary streams.

III. Summary

The unique features of the Lower Cumberland Basin include a large recreation area which is associated with Barkley Lake, Kentucky Lake and the Land-Between-the-Lakes. This recreational potential must be given high priority for the protection of localized contamination from waste facilities and for control of sediment loads to prevent siltation of embayment areas. The other feature which contributes to water quality changes is the "Karst" topography which increases hardness in tributaries and makes groundwater from solution channels and pools within caverns difficult to protect from bacterialogical contamination. In these areas groundwater is of questionable bacterialogical quality and extension of rural water supplies providing treated water should be encouraged.

Table D-1

Drainage Areas in the Lower Cumberland Basin

AREA DATA

COUNTY	TOTAL AREA	PERCENT AREA IN BASIN	AREA IN BASIN IN SQUARE MILES
Caldwell	357	44.7	160
Christian	726	63.6	462
Crittenden	365	21.8	80
Livingston	317	37.8	120
Logan	563	39.4	222
Lyon	254	83.8	213
Simpson	239	39.9	95
Todd	376	64.3	242
Trigg	457	83.1	380
		Total,	1,933

Source: This information was taken from Kentucky Water Quality Standards for Interstate Waters, Kentucky Water Pollution Control Commission, June, 1967.

Table D-2

Slope and Elevations of Streams in the Lower Cumberland Basin

Slopes

CREEK	AVERAGE(feet/mile)	ELEVATIONS Head	ELEVATIONS Mouth
South Fork Red River	5.28	530	468
Elk Fork	6.64	650	470
Big West Fork	6.44	600	400
Red River	4.4	600	450
South Fork Little River	7.58	660	475
Caney Creek	26.18	448	359
Little River	2.39	550	359
Dry Creek	15.17	450	362
Eddy Creek	4.15	450	359
Hammond Creek	27.9	490	359
Caldwell Springs	20.0	373	329
Crab Creek	17.87	428	319
Panther Creek	20.55	420	307
Livingston Creek	2.37	329	302
Cox Spring Branch	35.7	426	355
Sandy Creek	5.31	319	302
Clear Branch	22.0	330	319
Knob Creek	21.3	393	359
Lick Creek	4.4	370	359
Blue Spring Creek	0	359	359
Montgomery Creek	15	620	461
McCormick Creek	19.35	332	302

Note: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

Table D-3

Lakes in the Lower Cumberland River Basin

LAKES	VOLUME (Acre-Feet)	AREA(Acres)
Morris - North Fork Little River	1740	170.0
Boxley - North Fork Little River	2006	166.0
Blythe - North Fork Little River	1313	89.0
Barkley - Cumberland River	259,000	57,920

Source: Kentucky Department for Natural Resources and Environmental Protection Division of Water Resources.

Table D-4

Population in the Lower Cumberland Basin by County

COUNTY	TOTAL POPULATION IN COUNTY IN 1970 ***	POPULATION IN BASIN*
Caldwell	13179	9619
Christian	56224	43378
Crittenden	8493	1196
Livingston	7596	3762
Logan	21793	5919
Lyon	5562	5055
Simpson	13054	2594
Todd	10823	8140
Trigg	8620	7499
		87162

* Population in basin is found by taking rural population evenly distributed across the county and multiplying by percentage of area of the county in the basin. City populations are then added to this figure.

*** 1970 U.S. Census Data from Rand McNally Standard Reference Map and Guide of Kentucky.

Table D-5

Cities in the Lower Cumberland Basin

COUNTY	POPULATION	STATUS
Caldwell		
Princeton	6292	Step 1 - Pending
Fredonia	450	No Sewers
Christian		
Hopkinsville	21400	Step 1 - Under Way
Pembrook	634	
Crittenden		
Livingston		
Smithland	514	
Salem	480	Step 1 - Pending
Grandrivers	438	
Logan		
Adairville	973	
Lyon		
Eddyville	1981	Step 3
Kuttawa	453	
Simpson		
Todd		
Elkton	1612	
Guthrie	1200	Step 1 - Under Way
Trenton	496	
Trigg		
Cadiz	1987	Step 1 - Under Way
	38910	

NOTE: Project type is related to the type of grant applied for or received by each city. Type I if for preliminary studies necessary before design of the facility. Type 2 is the design phase of a facility and Type 3 is for the construction of a facility for the collection and treatment of domestic sewage.

The comments related to the status of the grant. Underway indicates the project type is funded. Pending indicates that application for a grant has been made and is pending approval and no sewers means when a grant is requested that it is for a complete and original system.

The source of this information was the 1970 U. S. Census and the FY 75 Construction Grants list for Kentucky.

Table D-6

Water Uses in Lower Cumberland River Basin

	Total (gpd)	Well (gpd)	Surface (gpd)
Municipal	5,210,000	395,000	4,820,000
Industrial	1,095,000	532,000	563,000

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table D- 7

Organic Loads Affecting Streams in the Lower Cumberland Basin

Length of streams to which treated organic loads are discharged		360 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		62 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	40 miles
	Industrial Discharges	2.4 miles
	Other Discharges	19.6 miles

Note: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q 10-7) low flow.

THE UPPER CUMBERLAND RIVER BASIN

The Upper Cumberland River Basin is of considerable historic significance to Kentucky. It is through Cumberland Gap near Middlesboro that Doctor Walker first came to the state in 1757. Daniel Boone also entered Kentucky from Virginia through Cumberland Gap and made his trek through most of the Lower Cumberland finally establishing settlements at Boonesboro on the Kentucky River. Much of the Upper Cumberland River Basin is relatively undisturbed with a wild river designated in the South Fork of the Cumberland River.

I. Basin Description

A. Basin Description

The Cumberland River originates at Harlan, Kentucky at the confluence of Poor Fork and Clover Fork 694 miles from its confluence with the Ohio River. The flow is generally in a westerly direction turning south below Lake Cumberland before flowing into Tennessee. The total basin drainage area in Kentucky is 5,077 sq. mi. with eight (8) sub-basins consisting of 200 sq. mi. or more.

B. Topography

The topography varies from mountainous in the upper portion or headwaters of the basin to hilly, with steep cliffs along the stream courses in the lower portion. Big Black Mountain, located in Harlan County is the highest elevation in Kentucky at 4,145 feet above sea level. The average slope of the streams in the entire basin is 14 feet per mile with the main stem above Lake Cumberland averaging approximately seven feet per mile (ft./mi.).

C. Geology

Most important of the geological features which affects water quality is the extensive coal deposits found at the upper region and throughout the majority of the entire basin. The middle portion of the basin, also, consists of high-calcium limestone deposits which lends to the hardness of the water. Petroleum producing areas and refineries are found in the lower portion of the basin which always possess the potential for oil spills or leaks. These are rare, but have a tremendous shock affect when they occur.

D. Hydrology

The average flow of the main stem of the Cumberland River in Kentucky is 4,293 cubic feet per second with an average yield of 1.67 cubic feet per square mile (See Table E-4). There exists ten (10) major lakes in the basin all possessing flood control capabilities and comprising a total surface area of 102,315 acres. Three of these lakes are Corps of Engineers' projects - Lake Cumberland, Laurel River and Dale Hollow Lake - with total surface area of 100,580 acres. Lake Cumberland is the largest of the lakes with an area of 63,530 acres and is used for power, recreation, and flood control purposes.

TABLE E-4

SURFACE WATER RECORDS FOR CUMBERLAND RIVER BASIN

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 day 10 yr. Low Flow
Rowena, Kentucky	35 yr.	5,790 sq. mi.	9,010 cfs, 1.6 cfs* / sq. mi.	162,000 cfs, 28.0 cfs / sq. mi.		93 cfs
Cumberland Falls	64 yr.	1,977 sq. mi.	3,184 cfs, 1.61 cfs / sq. mi.	59,600 cfs, 30.1 cfs / sq. mi.	4.0 cfs, 0 cfs / sq. mi.	26 cfs
Harlan	34 yr.	374 sq. mi.	686 cfs, 1.83 cfs / sq. mi.	43,200 cfs, 115 cfs / sq. mi.	3.0 cfs, 0.01 cfs / sq. mi.	20 cfs

* Cubic Feet Per Second

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

E. Population

Population in the basin can best be described as scattered. The total population in the basin is approximately 260,000 people based on 1970 census. The majority of the population is rural. The only two cities greater than 10,000 people are Middlesboro with 11,700 and Somerset with 10,500 (1970 census). Of the entire basin population, 25 per cent reside in Harlan and Bell counties which are located near the headwaters of the basin, and 77 per cent reside in the portion above Lake Cumberland. The portion of the population in headwaters is due to coal mining.

II. Basin Water Quality

A. Description of Sampling Stations

Data for which the discussion of water quality in this report is based was collected from four sampling stations. Three of these stations are located on the Cumberland River itself at (1) Harlan, (2) Barbourville, and one below Lake Cumberland at (3) Burkesville. The fourth is located on the Yellow Creek at Middlesboro selected to reflect the effects of a coal mining area and an industrial waste discharge. Total drainage area encompassed by these stations, including the portion in Tennessee, is 6,152 sq. mi. with the Harlan station, 374 sq. mi., the Middlesboro station, 103 sq. mi., Barbourville, 1,034 sq. mi., and Burkesville, 6,152 sq. mi.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

The general chemical water quality of the Upper Cumberland River Basin is characterized by Figures E-2 and E-3 which indicates a water with low mineralization as reflected by the hardness on E-2 and the combination of calcium and magnesium on E-3 which results in the equivalent hardness as shown in Burkesville.

The water quality shown on Yellow Creek is not typical of the river as a whole but was selected to indicate the effect of natural conditions and man-made conditions on water quality. The source of water quality of Yellow Creek is an impoundment known as Fern Creek some 1,000 feet above the city of Middlesboro. Middlesboro is situated in a geological structure. This area is filled with sedimentation containing a high amount of organic material and as a result of seepage from this material, high sulfates, tannins, lignens, and low D.O. upstream of any waste discharges cause a major modification of the water from Fern Lake which has very little mineralization to a poor quality water. The city of Middlesboro, in addition to treating the municipal waste, has a facility which treats tannery wastes which compounds the problem of increasing the mineralization and particularly the sodium chloride portion. The effects of coal mining will particularly be exhibited on Yellow Creek in Middlesboro in spite of the fact that sulfate concentrations is relatively high.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards. No problem exists in this basin with respect to these limits and standards.

D. Waste Load Effects on Water Quality

Biochemical degradable waste impose a load on the dissolved oxygen recourses of a stream. Such discharges affect water quality based upon the relationship between amount of discharge and amount of flow in the stream.

Also, as mentioned previously, the slope plays an important part in the ability of a stream to revive itself after being subject to organic waste loads. To determine the effects of waste loads on a stream a model has been developed in conjunction with the river basin planning effort and this model was used to determine the load effects on the streams. The Upper Cumberland Basin has a total of 752 miles of stream which carry effluent from treated organic loads. Of this total length, 176 miles are adversely affected by discharges, i.e., the dissolved oxygen level is predicted to be below 5 mg/l during period of low flow. It is interesting to note that of the 176 stream miles affected only 14 per cent of the length is affected by 90 per cent of total flow of the discharges. This 90 percent is composed of six (6) municipal discharges. The remaining discharges are small treatment plants scattered throughout the basin located on streams that normally possess zero flow during periods of most years.

E. Non-Point Source Effects

The topography of the area creates an inherent problem of erosion and sediment. Surface erosion is occurring on approximately 114 sq. mi. of rural areas, including surface mines, mine haul roads, logging roads and trails, log concentration yards, rural roads, streambanks, and utility rights-of way. This includes about 78 sq. mi. acres of inadequately treated croplands. Added to these figues are those sites in and around urban areas comprising approximately 9.5 sq. mi. that are being developed for residential, commercial, and industrial purposes.

Due to the growing urban areas of Middlesboro and Somerset runoff from these areas will increase the effect on the zero flow streams to which they are adjacent.

F. Water Uses

Of the many communities, industrial, and private users, three (3) withdraw over one million gallons per day. These are Middlesboro, Somerset and Corbin and they withdraw from surface waters for both industrial and public supply. The total basin withdrawal of all users is approximately 10,845,000 gallons per day of which 83 per cent is drawn from surface water and 70 per cent of the total is for public supply.

The Upper Cumberland Basin is a major area in the state with Lake Cumberland being the recreational main attraction, one of the large man-made lakes in the world. Also, Laurel River Lake and the portion of Dale Hollow Lake in Kentucky provide additional recreational facilities, as do the many smaller lakes in the area. This basin is considered one of the most important fishing areas of the state. Approximately 1,040 miles of stream are considered of fishery importance with some 440 miles affected by discharges.

G. Water Quality Changes

The water quality in the Upper Cumberland River Basin with the exception of that water quality in Yellow Creek and some of the tributaries above Harlan is excellent and low in mineralization and hardness. Any changes in water quality will be as a result of a marked increase in coal mining activities particularly in Harlan, Bell, Knott, and Whitley Counties. Waste from coal mining activities include acid mine drainage, however, the coal formations are not associated with high acid mine drainage production and sedimentation from surface disturbances particularly stripping and augering. The other effect on water quality where slight changes will occur is in the London-Corbin area where an ideal location for industrial development is expected to develop. The waste from this type of operation, however, is controllable and will not create major changes in the water quality of this area.

III. Water Quality Summary

Generally, it can be said the Upper Cumberland Basin is of good water quality. No where along the main stem does the dissolved oxygen content fall below the minimum standard concentration of 5 mg/l. As discussed, the tributaries, due to the scattered discharges and low stream flows, are affected in regard to water quality. Improvements may be made either by improving treatment where appropriate or by improving operation. With the continuing technological improvements, better qualified operators are needed with better training and higher salaries to insure integrity in the sewage treatment plant's operation and maintenance.

The coal mining boom, due to the energy crisis and the abundance of coal as a fuel, may have a devastating effect on the water quality of this basin. Increased non-point source discharge due to the additional clearing of land will cause erosion and coal solids concentrations to be higher. Proper construction and drainage controls are needed to insure that under normal conditions coal solids are not discharged into the waters of the basin. More point source discharges in the form of preparation plants and coal washers will develop but should be kept in control by state issued operation permits and inspection as is done now. Cooperation is needed between all persons involved so that the Upper Cumberland River Basin will not only serve as a vital natural resource area, but will retain its recreational and environmental appeal.

TABLE E-1

Sub-basins of 200 sq. mi. or Greater

Sub-basins		Square Miles
Clover Fork		222.0
Clear Fork		370.0
Laurel River		289.0
Rockcastle River		763.0
Bucky Creek		294.0
Clear Creek		283.0
South Fork Cumberland River		1,382.0
Beaver Creek		234.0
	Total	3,837.0

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE E-2

UPPER CUMBERLAND DRAINAGE AREA BY COUNTY

County	Total Area (sq. miles)	Area in Basin (sq. miles)	County	Total Area (sq. miles)	Area in Basin (sq. miles)
Adair	370	55	Letcher	339	50
Bell	370	355	Lincoln	340	80
Casey	435	44	McCreary	418	418
Clay	474	47	Metcalfe	296	45
Clinton	190	190	Monroe	334	110
Cumberland	310	310	Pulaski	653	653
Harlan	469	420	Rockcastle	311	251
Jackson	337	200	Russell	238	170
Knox	373	335	Wayne	440	440
Laurel	446	446	Whitley	458	458
			Total	7,601	5,077

SOURCE: Rand McNally Standard Reference Map and Guide of Kentucky, 1972.

TABLE E-3

Slopes and Elevations in Upper Cumberland River Basin

STREAM	LENGTH (Miles)	Max. El. (m.s.l.)	Min. El. (m.s.l.)	AVERAGE SLOPE (ft./miles)
Poor Fork Cumberland River	46.05	1,780	1,150	13.7
Yellow Creek	18.13	1,140	996	7.9
Clear Creek	4.82	1,194	985	43.4
Straight Creek	23.0	1,740	980	33.0
Clear Fork	18.6	938	896	2.3
Laurel Creek	10.31	1,340	955	37.3
Little Laurel River	19.3	1,160	1.030	6.7
Laurel River (above Lake)	30.05	1,200	982	7.3
Laurel River (below Lake)	2.3	767	737	13.0
Rockcastle River	69.2	1,015	723	4.2
Buck Creek	58.0	1,100	723	6.5
Pittman Creek	34.25	1,100	730	10.8
Cumberland River (above Lake)	190.8	2,049	723	6.95
Cumberland River (below Lake)	75.4	545	500	0.6

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE E-5

MAJOR LAKES IN THE UPPER CUMBERLAND RIVER BASIN

Location	County	Surface Area (Acres)	Capacity Acre-Feet
Cranks Creek	Harlan County	219	6,400
Fern Lake	Bell County	101	902
Wood Creek Lake	Laurel County	672	23,270
Renfro Lake	Rockcastle County	274	4,404
Corbin Reservoir	Laurel, Knox, and Whitley Counties	139	2,500
Tyner Lake	Jackson County	87	2.364
Cannon Creek Dam	Bell County	243	11,300
	Total ----------------	1,735	51,140
Federal			
Laurel River Lake	Laurel and Whitley Counties	6,060	435,600
Lake Cumberland	Clinton, Russell, and Wayne Counties	63,530	6,089,000
Dale Hollow Lake	Cumberland and Clinton Counties	30,990	1,706,000
	Total ----------------	100,580	8,230,000
	Grand Total ----------------	102,315	8,281,140

SOURCE: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

TABLE E-6

Organic Loads Affecting Streams in the Upper Cumberland River

Length of streams to which treated organic loads are discharged		752
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		176
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	25
	Industrial Discharges	---
	Other Discharges	151

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year, seven day, low flow.

TABLE E-7

POPULATION AND PROJECT PLANNING STATUS

County - Cities	Total Population	Population in Basin	Project Type	Comments
Adair	13,037	1,500	---	---
Bell	31,087	30,400		
Middlesboro		11,700	Step 1	Pending
Pineville		2,817	Step 1	Pending
Casey	12,930	1,100	---	---
Clay	18,481	1,700		
Clinton	8,174	8,174	---	---
Albany		1,891	Step 1	Underway
Cumberland	6,850	6,850	---	---
Burkesville		1,717	Step 1	Pending
Harlan	37,370	33,600	---	---
Harlan		3,200		
Loyal		1,212	Step 1	Pending
Evarts		1,182	---	No Sewers
Cumberland		3,624		
Benham		1,000		
Lynch		1,700	Step 1	Pending
Jackson	10,005	6,100	---	---
McKee		255	Step 1	Pending
Knox	23,689	21,900	---	---
Barbourville		3,549	Step 1	Pending
Corbin		2,000	See Laurel & Whitley	
Laurel	27,386	27,386		
London		4,377		
Corbin		532	Step 1	Underway
Letcher	23,165	5,300		
Lincoln	16,663	3,500	---	---
Crab Orchard				
McCreary	12,548	12,548	---	---
Whitley City		1,060		
Stearns		950	Step 1	Pending
Metcalfe	8,177	1,100	---	---
Monroe	11,642	3,100		

TABLE E-7

County - Cities	Total Population	Population in Basin	Project Type	Comments
Pulaski	35,234	35,234	---	---
Somerset		10,500	Step 1 & 3	Step 1 Underway
Burnside		586	Step 1	
Rockcastle	12,305	9,600	---	---
Mount Vernon		1,639	Step 1	Pending
Russell	10,542	8,300	---	---
Jamestown		1,027		No Planning
Russell Springs		1,641		No Planning
Wayne	14,628	14,628	---	---
Monticello		3,618		No Planning
Whitley	24,145	24,145		
*Corbin		4,785	See Laurel & Whitley	
Williamsburg		3,687	Step 1	Pending

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality.

TABLE E-8

WATER QUALITY DATA FOR UPPER CUMBERLAND RIVER BASIN

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End. Date
		pH Specific Units					
Yellow Creek at Middlesboro	57	7.0	0.4	8.3	6.4	5-64	3-73
Cumberland River at Burkesville	23	7.2	0.4	7.9	6.5	12-65	5-72
		Conductivity Micromhos					
Yellow Creek at Middlesboro	70	510	270	1,690	160	5-64	3-73
Cumberland River at Burkesville	25	150	10	170	120	12-65	5-72
		Dissolved Solids mg/l					
Yellow Creek at Middlesboro	5	480	300	970	270	10-67	7-72
		Alkalinity mg/l					
Yellow Creek at Middlesboro	23	82	63	330	22	5-64	3-73
Cumberland River at Burkesville	15	42	7	62	31	10-67	5-72
		Hardness, mg/l					
Yellow Creek at Middlesboro	57	170	65	290	54	5-64	3-73
Cumberland River at Burkesville	23	60	5	72	53	12-65	5-72
		Color, Platinum Cobalt Color Units					
Yellow Creek at Middlesboro	23	61	140	700	3.0	5-64	7-72
		Sodium, mg/l					
Yellow Creek at Middlesboro	7	88	73	230	31	9-64	7-72
Cumberland River at Harlan	6	30	21	65	11	4-73	10-74
Cumberland River at Barbourville	6	18	9	33	8	4-73	10-74

TABLE E-8
Pc...

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End. Date
	Potassium, mg/l						
Yellow Creek at Middlesboro	7	5.6	2.5	9.2	3.2	9-64	7-72
Cumberland River at Harlan	6	2.4	1.2	4.4	1.3	4-73	10-74
Cumberland River at Barbourville	6	2.2	0.8	3.4	1.5	4-73	10-74
	Chloride, mg/l						
Yellow Creek at Middlesboro	57	40	45	250	5	5-64	3-73
Cumberland River at Burkesville	23	3.8	0.8	5	2	12-65	5/72
	Sulfate, mg/l						
Yellow Creek at Middlesboro	57	130	120	1,000	40	5-64	3-73
Cumberland River at Burkesville	23	27	3.9	36	21	12-65	5-72
	Nitrate, mg/l						
Yellow Creek at Middlesboro	6	2	2	5	0.7	11-71	3-73
	Fluoride mg/l						
Yellow Creek at Middlesboro	30	0.2	0.2	0.7	0	5-64	3-73
Cumberland River at Burkesville	5	0.1	0.1	0.1	0	12-66	9-71
Cumberland River at Harlan	57	0.4	0.3	0.9	0.1	1-70	11-74
	11	0.6	0.3	0.9	0.1	1-74	11-74
Cumberland River at Barbourville	56	0.5	0.3	0.9	0.3	1-70	11-74
	11	0.6	0.2	0.9	0.3	1-74	11-74
	Calcium, mg/l						
Yellow Creek at Middlesboro	22	46	17	79	17	5-64	7-72
Cumberland River at Harlan	5	15	7	26	8	5-73	10-74
Cumberland River at Barbourville	5	14	5	24	9	5-73	10-74

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End. Date
	Magnesium, mg/l						
Yellow Creek at Middlesboro	22	19	6	29	9	5-64	7-72
Cumberland River at Harlan	5	7.8	2.9	12.2	4.6	5-73	10-74
Cumberland River at Barbourville	5	7.1	1.6	10.0	6.1	5-73	10-74
	Cadimum, micrograms per liter						
Cumberland River at Harlan	57	0.8	0.6	3	0	1-70	11-74
	11	1.2	0.6	2	0	1-74	11-74
Cumberland River at Barbourville	56	0.9	1.3	9	0	1-70	11-74
	11	1	0.6	2	0	1-74	11-74
	Maganese, micrograms per liter						
Yellow Creek at Middlesboro	5	230	160	410	0	10-66	1-73
	Iron, micrograms per liter						
Yellow Creek at Middlesboro	5	200	180	470	30	10-66	1-73
	Chromium, micrograms per liter						
Cumberland River at Harlan	56	1.6	1.9	10	0	1-70	11-74
	11	2.3	2.0	8	1	1-74	11-74
Cumberland River at Barbourville	56	2.1	1.4	5	0	1-70	11-74
	11	1.8	0.9	3	1	1-74	11-74
	Lead, micrograms per liter						
Cumberland River at Harlan	56	11	8.1	58	1	1-70	11-74
	11	11	7.9	33	3	1-74	11-74
Cumberland River at Barbourville	53	18	17	104	1	1-70	11-74
	11	22	14	41	2	1-74	11-74

TABLE E-8

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End. Date
	Silver, micrograms per liter						
Cumberland River at Harlan	57	0.46	0.5	2	0	1-70	11-74
	11	0.36	0.5	1	0	1-74	11-74
Cumberland River at Barbourville	56	0.52	0.9	6	0	1-70	11-74
	11	0.36	0.5	1	0	1-74	11-74
	Arsenic, micrograms per liter						
Cumberland River at Harlan	16	0.81	0.81	3	0	1-70	7-74
Cumberland River at Barbourville	16	0.56	0.61	1	0	1-70	7-74

THE GREEN RIVER BASIN

The Green River Basin is located in West Central Kentucky and Northern Tennessee. The first section of this report will deal with the general description of the area. The second section will enter into an analysis of the water quality in the basin, its causes and effects. The third section of the report summarizes the water quality of the basin and the correction needs.

I. A Description of the Green River Basin

A. Geography

The Green River Basin is located in West-Central Kentucky and in Northern Tennessee. It comprises a total drainage area of 9,229 sq. mi., with 8,821 in Kentucky and 408 in Tennessee. The Green River Basin encompasses all or portions of 31 counties in Kentucky and 3 in Tennessee. (The Kentucky County Areas are listed in Table F-1 of the Appendix). The Green River is a tributary of the Ohio River, the confluence of the Green River with the Ohio River is 197 miles above the mouth of the Ohio River. The main tributaries of the Green River are the Barren, Nolin, Pond and Rough Rivers. These and other sub-basins with drainage basin areas over 200 sq. mi. are listed in Table F-2 in the Appendix.

B. Topography

The primary interest is in the character and slopes of the land and the streams within the basin as they affect water quality. The slope of the land is one of the variables which contributes to water quality. The character indicates the type of land over which the runoff travels before entering the stream. The largest portion of the Green River Basin is in the physiographic region known as the Mississippian Plateau which can be characterized as gently rolling fields, rocky hillsides, and Karst topography. Karst topography has many sinkholes, underground solution channels and caves. Some wastewater treatment plants and storm water runoff are discharged in the underground formations since the region is without surface streams. The second largest physiographic region is the Western Kentucky Coal Fields with somewhat higher elevations and generally more rugged than the Mississippian Plateau Region. The Mississippian Plateau Region has a lower quantity of runoff and higher runoff quality than the Western Kentucky Coal Field Region.

The quality of the water in a stream can be influenced by the slope of the stream. This effect is demonstrated in the direct relationship between the slope and the capacity of the stream to assimulate waste loads through reaeration. A stream slope of 2 ft./mi. or less produces a low rate of reaeration. A stream slope between 2 and 6 ft./mi. produces a moderate rate of reaeration. Slopes between 6 and 10 ft./mi. produces a high rate of reaeration. The main stem of the Green River flows into the Ohio River at elevation 338 feet above mean sea level (m.s.l.) and is controlled by a series of six locks and dams for navigational purposes. These structures with mile points and pool lengths are listed in Table F-3. Past these structures the river then rises at a gradual slope of 1.6 ft./mi. to the Green River Reservoir at elevation 600 feet above m.s.l. The tributary slopes range from 0.8 ft./mi. to 3 ft./mi. in the lower reaches and 4.7 ft./mi. to 7.7 ft./mi. in the upper regions and the highest elevation is 1,040 feet above m.s.l. A complete list of slopes is included in Table F-2 of the Appendix.

C. Geology

Surface water quality in the Green River Basin is affected by the parent bedrock, mineral resources and groundwater. The base parent material for most of the Green River Basin is limestone bedrock which produces a bicarbonate type hardness in the water. The Pond River and Rough River sub-basins have sandstone and shale rock layers which produce a sulfate type hardness in the water.

The major mineral resources of the Green River Basin are coal, oil and gas with coal being the largest resource. Generally, coal production in this basin increases acidity and mineralization in the stream. Approximately 40 million tons of coal was produced in the basin in 1972, 94% of which was mined in 3 counties, Muhlenberg (65%), Ohio (16%) and Hopkins (13%). These and other county coal productions are listed in Table F-4 of the Appendix. Approximately 75% of the basin's production in 1972 was done by strip mining on 12.5 sq./mi. A "Soil Conservation Service" basin study indicates about 264 sq./mi. of strip mineable coal still exists. The Green River Basin contributed one-third of the total coal production in 1972, and it has been estimated that coal production in Kentucky by 1985 will reach 400 million tons per year, 3 1/3 times the 1972 figure. A copy of the Commonwealth of Kentucky strip mining slope regulations is included in Table F-5 of the Appendix.

Other mineral resources in the Green River Basin are oil and gas. Oil wells in Kentucky can produce a brine as a waste product. Disposal of brine water other than by reinjection could degrade water quality. In the Green River Basin oil and gas production are not expected to increase in the future.

An important groundwater effect on water quality is the increase in assimilative capacity of the stream due to the substantial amounts contributed to the base flow by springs in the Mississippian Plateau during period of low flow.

Groundwater yields in the Green River Basin range from 50 gallons per minute (g.p.m.) or less in 75 percent of the basin, 50-500 g.p.m. in approximately 24 percent of the basin and 500 to 1,000 g.p.m. in approximately 1 percent of the basin. A map of these regions is included in the Appendix.

D. Hydrology

The stream flow of the Green River Basin was obtained at six stations: (1) Nolin River at Kyrock, (2) Barren River at Bowling Green, (3) Rough River at the Falls of the Rough River and on the main stem of the (4) Green River at Munfordsville, (5) Lock Number 4 and (6) Lock Number 2. The low flows at all of these stations were augmented by Corps of Engineer Reservoirs. The low flow period for once in 10 years for 7-days is adjusted to include flow augmentation provided by the impoundments. The yields without augmentation are low and a large drainage basin area is needed before a flow occurs. In the Barren River Basin 100 sq. mi. of drainage area will be needed for 2 cubic feet per second/square mile (c.f.s./sq.mi.) of low flow. Because of this flow condition water quality becomes increasingly difficult to maintain during periods of low flow.

GREEN RIVER BASIN FLOW DATA

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 Day 10 yr. Low Flow
Nolin River at Kyrock, Kentucky	25 yr.	707 sq. mi.	860 cfs 1.22 cfs / sq. mi.	22,700 cfs 32.11 cfs / sq. mi.	0 cfs 0 cfs / sq. mi.	50.0 cfs 0.07 cfs / sq. mi.
Barren River at Bowling Green, Kentucky	35 yr.	1,848 sq. mi.	2,442 cfs 1.32 cfs / sq. mi.	85,000 cfs 46.00 cfs / sq. mi.	44 cfs .02 cfs / sq. mi.	116.0 cfs 0.06 cfs / sq. mi.
Rough River at Falls of Rough, Kentucky	25 yr.	504 sq. mi.	726 cfs 1.44 cfs / sq. mi.	12,400 cfs 24.60 cfs / sq. mi.	6 cfs .01 cfs / sq. mi.	50.0 cfs 0.10 cfs / sq. mi.
Green River at Munford-ville, Kentucky	47 yr.	1,673 sq. mi.	2,598 cfs 1.55 cfs / sq. mi.	76,800 cfs 45.91 cfs / sq. mi.	39 cfs .02 cfs / sq. mi.	152.4 cfs 0.90 cfs / sq. mi.
Lock No. 4	36 yr.	5,403 sq. mi.	7,842 cfs 1.45 cfs / sq. mi.	205,000 cfs 37.94 cfs / sq. mi.	200 cfs .04 cfs / sq. mi.	319.9 cfs 0.06 cfs / sq. mi.
Lock No. 2	43 yr.	7,564 sq. mi.	10,730 cfs 1.42 cfs / sq. mi.	208,000 cfs 27.50 cfs / sq. mi.	280 cfs .04 cfs / sq. mi.	319.9 cfs 0.04 cfs / sq. mi.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

The Karst topography (see Topography) has an influence on the hydrology of the Green River Basin. The sinkholes and underground solution channels store the runoff water during periods of high flows and discharge, through the springs mentioned in the Geology section, the stored volume, after the peak flow in the stream has passed.

In addition to the streams mentioned there are 13 major lakes located within the basin, (Table F-7 of the Appendix). Nine of these are multiple purpose structures, two slurry dams for Peabody Coal Company, one flood retardent structure and one for recreation purposes. There are 4 Corps of Engineers Reservoirs with a total area of 29,090 acres at seasonal pool with a total volume of 532,000 acre feet. They are the Nolin River, Green River, Barren River, and Rough River reservoirs. They are all designed and operated for flood control, recreation, low flow augmentation and fish and wildlife purposes, and in addition the Green, Barren and Rough River Reservoirs have volume allocated for water supply. Lakes by the U.S.D.A. Soil Conservation Service and others have 32,200 acre feet of volume. These lakes have no volume allocated or discharge structure needed for low flow augmentation.

E. Population

The total population in the basin is 426,000 which is distributed uniformly except for major population centers located in Warren (Bowling Green; 36,400), Hardin (Elizabethtown; 11,700), Barren (Glasgow; 11,300), Hopkins (Madisonville; 15,300), and Muhlenberg (Greenville-Central City; 9,330) counties. Of these major cities Madisonville, Elizabethtown and Glasgow discharge to zero flow streams and have a measurable impact on water quality. Populations of the other basin counties are listed in Table F-8 of the Appendix with the municipalities listed in Table F-9 of the Appendix. The basin population is 35 percent urban and 65 percent rural.

II. Basin Water Quality

A. Description of Sampling Stations

The recorded water quality of the basin is presented along with some of the major causes and effects. Also presented are the major uses of surface water in the basin description of the water sampling stations.

There were four stations used in this report to describe the typical water quality within the basin. The first station is on the main stem of the Green River at Munfordville covering 1,673 square miles (sq. mi.) or 18% of the Green River Basin. The second station is located at Bowling Green covering 1,848 sq. mi. or 82% of the Barren River Sub-basin. The third station is on the Green River approximately mid-river at Central City with 6,300 sq. mi. or 68% of the basin area above the station. The fourth station is on the main stem of the Green River near its mouth at Lock No. 1 covering 9,181 sq. mi. or 99% of the basin.

The Pond River near Sacramento was chosen to describe the effect of coal production, on water quality in the Green River Basin. This station is located in the heart of the coal production of Western Kentucky, also some oil production occurs. The drainage area at the station is 523 sq. mi. or 65% of the Pond River Sub-basin. The following discussion of parameters is based upon the data included in Table F-10 of the Appendix.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 - 25 parts per million as an average value.

The four reporting stations for general water quality reflect different situations on the river.

The Munfordville Station is near the headwaters but below the Green River Reservoir with 18% of the drainage area of the basin. This station has wide fluctuations between average and maximum value (Figure F-1). This station shows water quality in excess of those for Kentucky water particularly the high levels of sodium-(potassium) and chlorides. This can be attributed to an oil boom in Green and Taylor Counties which produced 10 million barrels in 1959. However, the graph for last year's data (Figure F-2) indicates these levels have decreased to pre-oil field conditions due to the decrease in oil production and an increase in control measures.

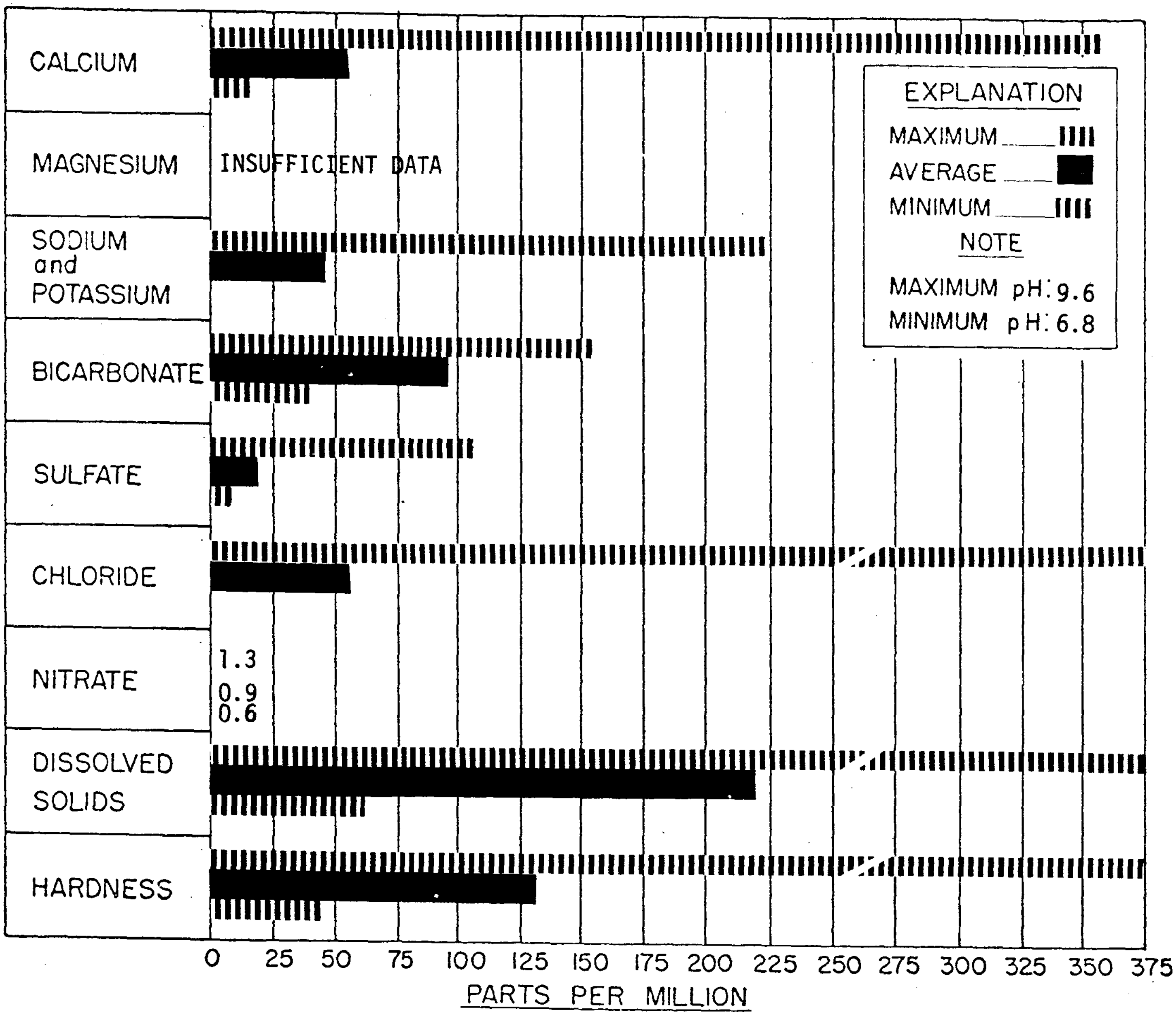
The station on the Barren River at Bowling Green has approximately the same size drainage basin area as the station at Munfordville but the station at Bowling Green shows a stable water quality which is attributed to the Barren

River Reservoir. The graph (Figure F-3) indicates that the natural water quality of the Barren River Basin is a bicarbonate type water with most mineralization (dissolved solids) in the form of calcium bicarbonate.

The Pond River at Sacramento was chosen to depict the influence of coal product on a small drainage basin. Every paramenter (Figure F-4) has a higher level in the Pond River except the bicarbonate, which is a measure of the stream's capacity to neutralize acids which demonstrates the effect of acid mine drainage on water quality depleted by acid mine drainage. The bicarbonates have been depleted by acid mine drainage and the effect is also shown by an average pH value of 4.9 with a minimum value of 2.8. To meet the energy crisis coal production is expected to increase over three times the present rate in Kentucky. The effects of coal mining on the Pond River water quality emphasized the influence that a marked increase in coal mining in the Green River Basin can produce on the basin water quality.

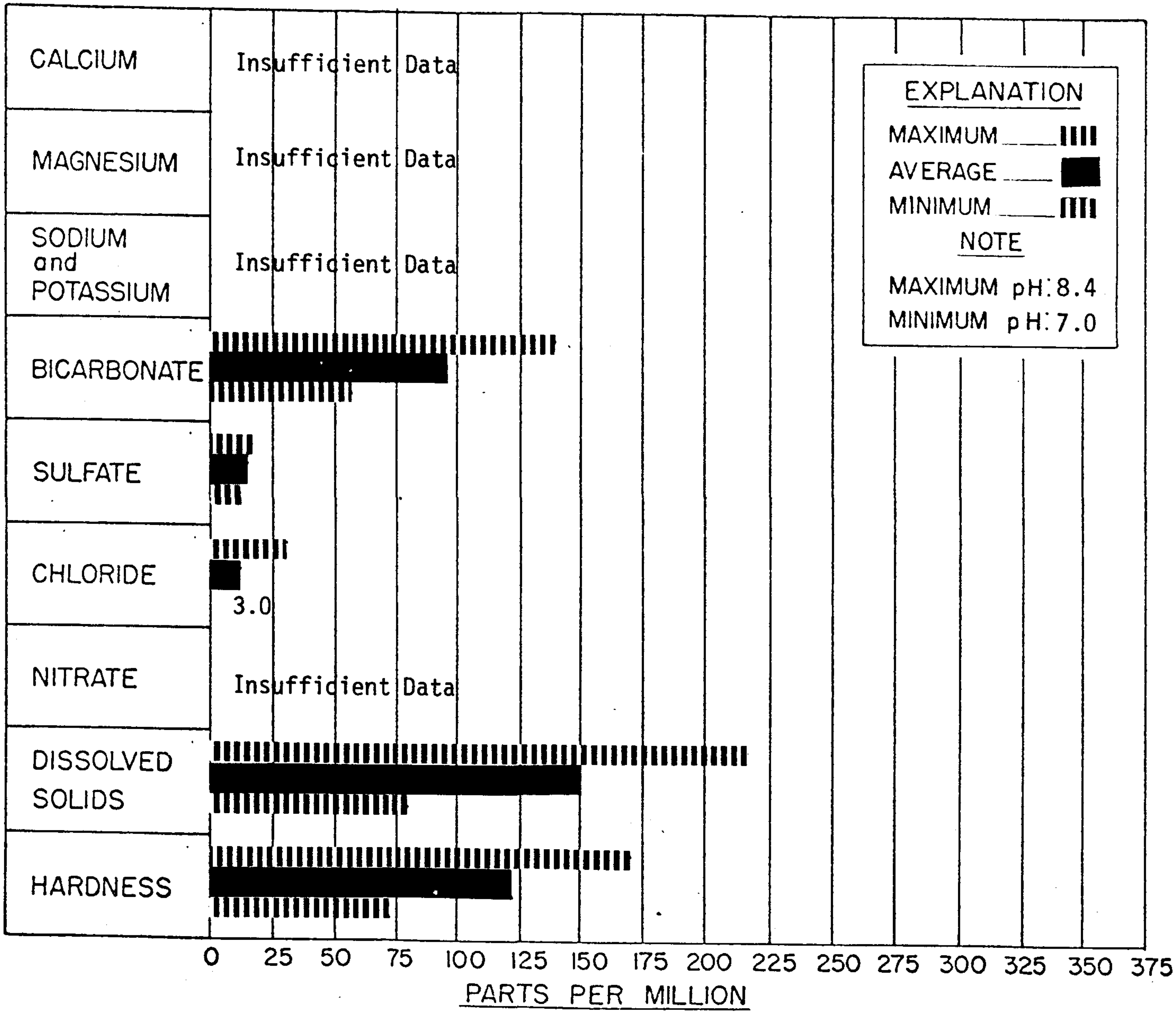
The effect of energy related resource development is indicated by comparison (Figure F-5) of the Green River Station at Lock No. 1 (covering 99% of the basin) with the Barren River Station (Figure F-3). The decrease in dominance of the bicarbonate hardness over the sulfate hardness clearly illustrates the increasing influence of coal production on the Green River Basin. The relatively high levels of sodium-(potassium) and chlorides reflect the past influence of the oil production throughout the basin.

At this time, the chemical water quality in the Green River Basin is good, but the demand for coal could have disasterous and long lasting effects on the water quality in the portions of the Green River Basin downstream from these developments. The influence of coal production is long lasting because there is no effective means, known at this time, of treating or elimating acid mine drainage on a large scale.



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Green River at Munfordville

Period of Record: 1-61 to 9-73

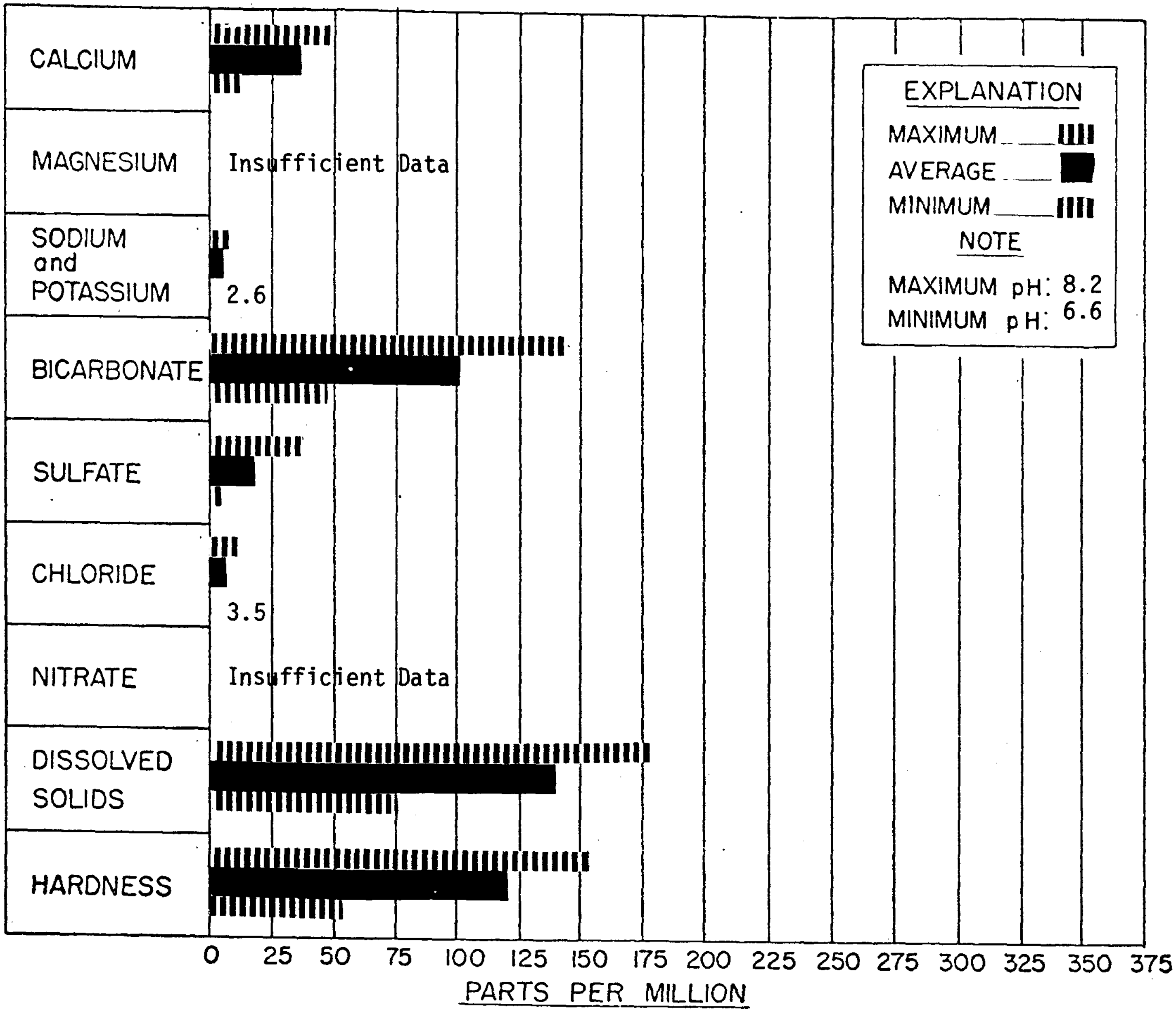


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Green River at Munfordville

Period of Record: 1-73 to 9-73

Figure F-2

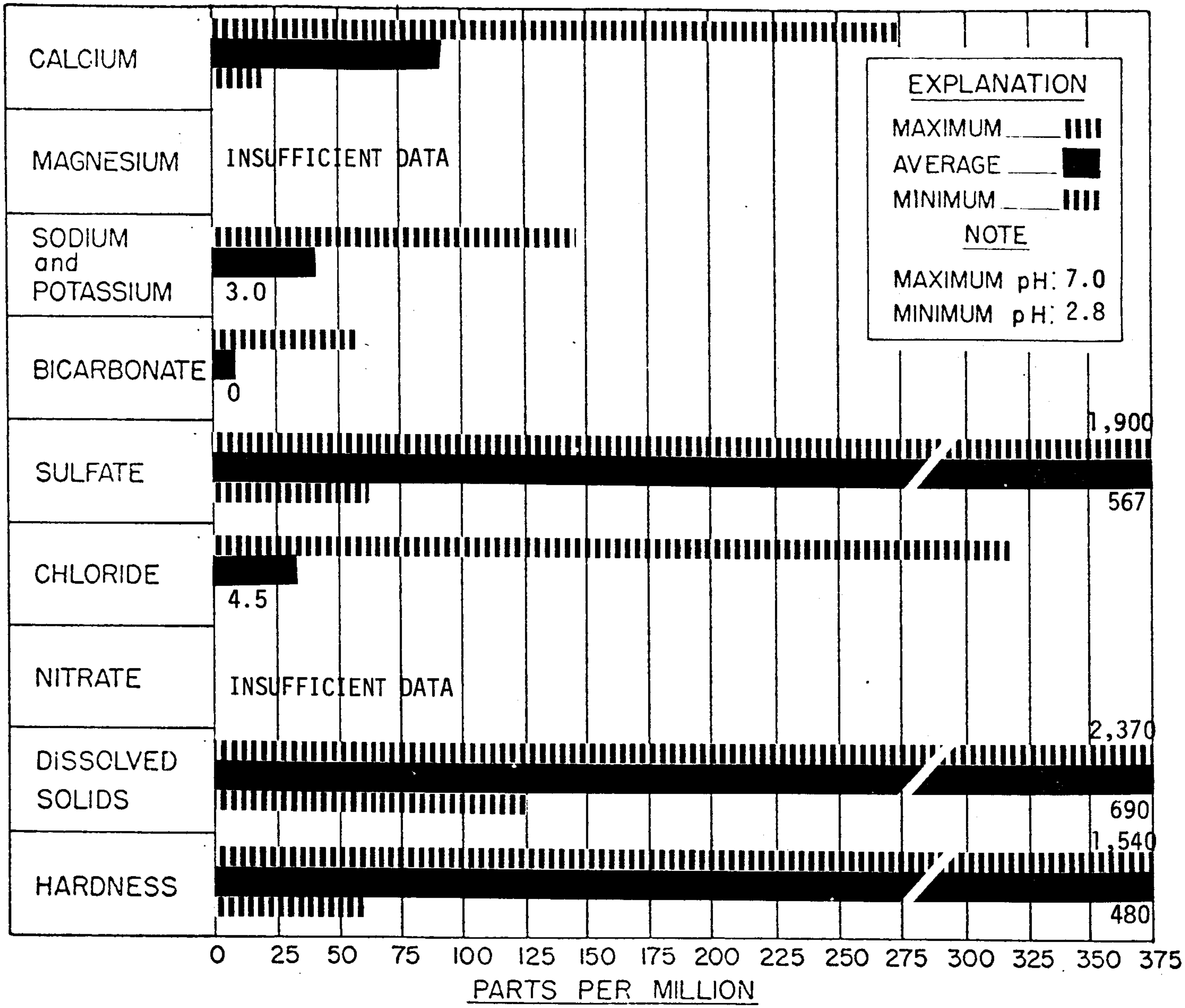


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Barren River at Bowling Green -

Period of Record: 10-59 to 4-74

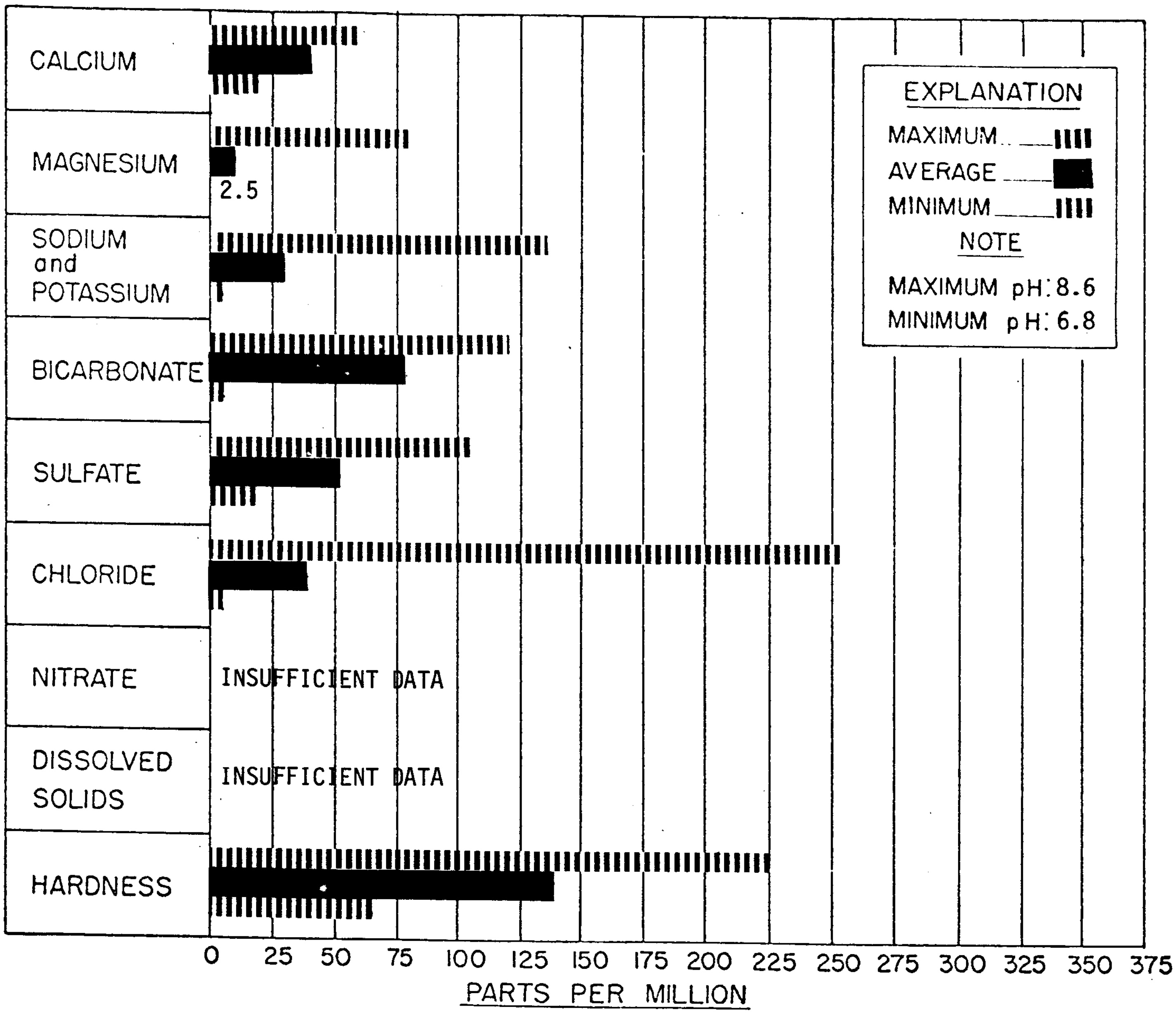
Figure F-3



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Pond River, Sacramento

Period of Record: 10-59 to 6-73

FIGURE F-4



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Green River at Lock 1

Period of Record: 10-59 to 8-72

C. Trace Chemical Water Quality

Trace elements under 5.0 mg/l are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

As a part of the monitoring strategy for Kentucky "Special Surveys" will be undertaken to determine the causes of these levels.

D. Waste Load Affect on Water Quality

Biochemical degradable waste impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an adverse effect on water quality when they cause the dissolved oxygen (D.O.) concentration of the water to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Approximately 1,670 miles of stream length were studied using a model to determine waste load allocation. The model was developed for the Kentucky Continuing Planning Process for River Basin Management Planning. Using this model it was determined that approximately 214 miles (12.8 percent) of that length would have a D.O. concentration of less than 5.0 mg/l when the flow is equal or less than the ten year seven day low flow for this period is zero in many of the tributaries and zero flow is expected to occur in small tributaries during most years.

There were 214 miles of stream length affected, of which 172 miles (10.3 percent) will be affected by municipal discharges, 7 miles (0.4 percent) are affected by industrial discharges and 34 miles (2.1 percent) are affected by other discharges such as schools, trailer parks, subdivision, etc. These results are listed in Table F-11 in the Appendix.

E. Non-Point Source Effects

The major non-point sources in the Green River Basin are acid mine drainage, siltation, agricultural runoff, and storm drainage from large cities located near low flow streams. The acid mine drainage and much of the siltation is caused by the coal production which is located primarily in Muhlenberg, Hopkins and Ohio Counties. Small receiving streams affected by acid mine drainage cannot support permanent fish life, and water quality is deteriorated by major increases in hardness (calcium sulfate). A map showing the streams constantly affected by mining is included in the Appendix. Oil production (ten million barrels per year) in Kentucky results in some brine waste, the influence on water quality in the Green River Basin is revealed from the Water Quality graphs.

A Soil Conservation Service report indicates 18 million tons of sediment from erosion is entering the Green River stream system annually.

1. 53 percent of the sediment is produced by erosion from the basin's cropland.
2. 25 percent of the sediment is produced by gully erosion.
3. 12 percent of the sediment is produced by erosion from disturbed forest lands.
4. 10 percent of the sediment is produced from erosion on previously surface mined lands, newly disturbed surface mined lands, 1,600 miles of roadbank erosion and 600 miles of streambank erosion.

siltation impact has been reduced by silt retaining structures, diversion ditches and terraces, but this phenomena will represent a significant problem until quick vegetative cover and good soil conservation practices are universally applied.

Storm water runoff from large cities could represent a significant non-point source where this runoff enters a stream with a small dilution ratio. The cities in the basin in this category are Glasgow, Elizabethtown and Madisonville.

F. Water Uses in the Basin

Water uses in the basin are public, industrial, recreational, and fish and wildlife and agricultural.

Public water use consists of 18.6 millions gallons per day, 14.7 million gallons per day of which is from surface water sources and 3.7 million gallons per day is from groundwater sources.

Industrial water usage consists of 10.5 million gallons per day, 9.8 million gallons per day of which is from surface sources and 776,000 gallons per day is from groundwater sources. A complete table for public and industrial water usage (Table F-12) is included in the Appendix.

Approximately 96,000 acres of land and 35,000 acres of water are used for recreational purposes in the area. Four Corps of Engineers' developments account for 29,000 acres of water and 34,000 acres of adjacent land. In 1969, the attendance at the four reservoir areas was nearly 2.9 million visitor days, the Rough River had 1,162,500 visitor days, the Nolin River had 345,500, the Barren River had 875,200, and the Green River had 509,400 visitor days.

Other recreational opportunities exist on 2,600 acres of water in completed PL 566 United States Department of Agriculture, Soil Conservation Service watershed developments and about 3,400 acres of water in State, County, City and privately owned developments.

Habitat for aquatic wildlife and fishes in the basin is provided by 87 principal streams with a total length of 1,600 miles: four large Corps of Engineers' water impoundments; seven other lakes over 100 acres; and numerous smaller lakes and farm ponds. There are 190 species of fishes found in Kentucky and probably 75 percent of these can be found in the Green River Basin.

Generally, water in the basin is widely used in the agricultural industry, primarily for livestock watering with a small amount used for irrigation. In the Pond River sub-basin, water quality is sufficiently degraded that it is not accepted for agricultural usage.

III. Summary

Water Quality in the Green River Basin is generally good. The water is slightly basic, hard, slightly salty and low in sulfates. Attention is needed, however, in the streams where coal is being produced. Since coal is expected to increase dramatically, the influence on the rest of the basin is likely to become pronounced. Also, 21 municipal discharges need to be upgraded to meet a dissolved oxygen (D.O.) concentration of 5.0 mg/l during periods of low flow. The trace chemical water quality in the Green River Basin is good with the exception of the periodic high lead levels in the Green River at Munfordville and the high fluoride levels in the Pond River at Sacramento. The exact causes of these phenomena are not known at this time and further study is needed. Further study is also needed for the quality of storm water runoff leaving large cities and developed areas and entering small streams.

TABLE F-1

Drainage Areas in the Green River Basin

	COUNTY AREA (SQ.MI.)	PORTION OF COUNTY (SQ.MI.)	% OF COUNTY IN BASIN
Adair	393	353	90
Allen	364	364	100
Barren	486	486	100
Breckinridge	564	243	43
Butler	443	443	100
Casey	435	341	79
Christian	726	161	22
Daviess	462	378	82
Edmonson	304	304	100
Grayson	512	512	100
Green	282	282	100
Hancock	187	29	16
Hardin	616	400	65
Hart	425	425	100
Henderson	433	121	28
Hopkins	553	278	50
Larue	260	171	65
Lincoln	340	60	17
Logan	563	329	58
McLean	257	257	100
Metcalfe	296	258	87
Monroe	334	225	68
Muhlenberg	481	481	100
Ohio	596	596	100
Pulaski	654	0.1	0.1
Russell	238	67	28
Simpson	239	143	60
Taylor	284	284	100
Todd	376	137	37
Warren	546	546	100
Webster	339	141	42
Sub total	12,988.00	8,821	68
Tennessee Area		408	
Total Drainage Basin		9,229	

Source: Soil Conservation Service Type IV Draft river basin report for the Green River, 1975

Table F-2

Slopes of Streams in the Green River Basin

Sub-basin		Average Slope (feet/mile)	Drainage Area (mi^2)
Russell Creek		5.4	289
Little Barren River		7.7	282
Nolin River -	Upper Reaches	4.7	727
	Lower Reaches	2.5	
Barren River -	Upper Reaches	7.7	2,262
	Lower Reaches	1.0	
Mud River		3.0	375
Rough River		0.8	1,081
Pond River		1.9	799
Panther Creek		1.5	374
Green River -	Upper Reaches	6.6	9,229
	Lower Reaches	n/a	

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort.

Table F-3

Locks and Dams in the Green River Basin

Lock and Dam	Mile	Length of Pool	Pool Elevation
1	9	54	349
2	63	45	363
3	108	36	380
4	145	23	396
5	168	14	411
6	182	18	421
Green River Reservoir	306		

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources

Table F-4

Coal Production by County and Type of Mining
in the Green River Basin

County	Coal Mining Methods (Tons) Strip	Underground	Auger	Total
Butler	133,100	71,100	--	204,200
Christian	80,500	--	--	80,500
Daviess	1,012,400	--	--	1,012,400
Henderson	--	92,600	--	92,600
Hopkins	2,333,600	2,752,300	76,000	5,162,600
McLean	1,108,700	--	--	1,108,700
Muhlenberg	20,843,600	5,104,200	136,000	26,083,800
Ohio	4,899,500	1,535,800	--	6,435,300
Totals	30,411,400	9,556,000	212,700	40,180,100
Percent of Totals	75	24	1	100

Source - Annual Report of the Department of Mines and Minerals for Kentucky, 1973.

Table F-5

Allowable Bench Width in Strip Mining

Slope in Degrees	Maximum Bench Width
12° - 14°	220'
15° - 18°	170'
19° - 20°	155'
21°	140'
22°	130'
23°	120'
24°	110'
25°	100'
26°	90'
27°	80'
Auger Only	
28°	60'
29° - 30°	55'
31° - 33°	45'
33° + No Fill Bench	

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Reclamation

Table F-6

Oil Production by County for Selected Years in the Green River Basin

County	1969	1970	1971	1972
			Year -Barrels-	
Adair	7,545	275,930	330,750	293,334
Allen	61,850	47,398	39,123	36,073
Barren	11,413	10,106	12,343	11,186
Breckinridge	5,248	5,648	7,766	7,666
Butler	62,124	54,290	47,008	59,827
Casey	12,698	11,872	7,325	5,274
Christian	40,223	38,735	38,293	33,737
Daviess	997,693	786,376	720,236	584,490
Edmonson	449	428	510	368
Grayson	---	---	---	---
Green	112,019	71,042	62,950	44,604
Hancock	11,990	11,426	11,341	10,230
Hardin	---	---	---	---
Hart	16,670	15,390	15,455	13,171
Henderson	555,931	477,206	397,706	328,492
Hopkins	427,640	396,358	414,692	354,246
Larue	---	---	---	---
Logan	746	1,496	741	391
McLean	686,140	584,665	551,354	558,665
Metcalfe	81,638	74,030	62,142	486,541
Monroe	15,447	15,006	12,536	10,955
Muhlenberg	405,689	346,307	300,467	253,187
Ohio	467,421	385,412	328,608	276,390
Pulaski	---	---	---	---
Russell	158	45	49	356
Simpson	2,303	6,744	7,074	6,033
Taylor	43	255	78	---
Todd	55	---	389	453
Warren	23,770	22,364	20,380	21,919
Webster	367,382	281,785	270,452	298,728

Source: Soil Conservation Service Type IV Draft River Report for the Green River, 1975

Table F-7

Lakes in the Green River Basin

Corps of Engineers Impoundments	Seasonal Capacity	Seasonal Area
Barren River Lake	190,280	10,000 AC
Rough River Lake	90,210	5,100 AC
Nolin Lake	170,200	5,790
Green River Lake	81,500	8,200
Total	532,190 AC-Ft.	29,090 AC

Other Impoundments Over 100 Acres	Capacity (AC-Ft.)	Area (AC)
Lake Herndon	2,265	147
Valley Creek MPS#4	1,830	160
Lake Malone	14,250	826
Shanty Hollow Lake	1,607	135
Big Muddy Creek F.R.S.#2	375	105
Mill Creek MPS#4	1,705	109
Mud River MPS#6A	3,218	240
Peabody Coal - New River Queen Slurry Dam	3,907	162
Peabody Coal - Alston Mine-Area VI Dam	1,180	50
Total	30,330 AC-Ft.	1,930 AC

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources

TABLE F-8

Population Distribution in the Green River Basin

COUNTY	1970 URBAN POPULATION**	TOTAL RURAL	TOTAL POPULATION* IN BASIN
Adair	3234	9803	12,100
Allen			12,600
Barren			28,700
Breckinridge	4235	10554	4,550
Butler			9,720
Casey	1765	11165	8,760
Christian	22665	33559	7,450
Daviess	51081	28405	24.000
Edmonson			8,750
Grayson			16,500
Green			10,400
Hancock	2857	4223	670
Hardin	26520	51901	45,800
Hart			14,000
Henderson	23856	12175	3,400
Hopkins	23637	14530	27,900
Larue	3114	7558	8,100
Lincoln	3748	12915	2,270
Logan	9240	7607	15,900
McLean			9,060
Metcalfe	958	7219	7,250
Monroe	2766	8876	8,760
Muhlenberg			27,500
Ohio			18,800
Pulaski			0
Russell	2668	7874	2,210
Simpson	6553	6501	10,500
Taylor	7598	6540	17,000
Todd	3308	7515	2,530
Warren			57,400
Webster	7865	5417	3,620
Total	150,000	276,000	426,000

* Approximate measurement ± 10 per cent based on U.S. Census Data

** U. S. Census Data

Table F-9

Municipalities in the Green River Basin

County	City	Population	Project Type	Comments
Adair	Columbia	3,234	I	Pending
Allen	Scottsville	3,584	I	
Barren	Cave City	1,818	None	
	Park City	567		No sewers
	Glasgow	11,301	III	STP only
Breckinridge				
Butler	Morgantown	1,394	I	
Casey	Liberty	1,765	I	Pending
Christian				
Daviess	Whitesville	752	I	No sewers
Edmonson	Brownsville	542	None	
Grayson	Caneyville	530		No sewers
	Clarkson	660		No sewers
	Leitchfield	2,983	I	
Green	Greensburg	1,990	None	
Hancock				
Hardin	Sonora	390		No sewers
	Elizabethtown	11,748	I	
Hart	Munfordsville	1,233	None	
	Horse Cave	2,068	None	
	Bonnieville	328	I	No sewers, pending
Henderson				
Hopkins	Earlington	2,321	I	
	Hanson	378	I	No sewers, pending
	Morton's Gap	1,169		No sewers
	Nortonville	699		No sewers
	White Plains	729		No sewers
	Madisonville	15,332	I	

Source: Kentucky Department for Natural Resources and Environmental Protection
Division of Water Quality

Table F-9
Continued

County	City	Population	Project Type	Comments
Larue	Upton	552		No sewers
	Hodgenville	2,562	I	
Lincoln				
Logan	Auburn	1,160	None	
	Lewisburg	651	None	
McLean	Calhoun	901	None	
	Sacramento	437		No sewers
	Island	410	I	No sewers
	Livermore	1,594	I	
	Calhoun	901	III	STP only
Metcalfe	Edmonton	958	None	
Monroe	Gamaliel	431		No sewers
	Tompkinsville	2,207	I	Pending
	Fountain Run	128	I	
Muhlenberg	Powderly	631		No sewers
	Drakesboro	907	I	No sewers
	Greenville - Central City	9,325	I	Pending
Ohio	Beaver Dam	2,622	None	
	Hartford	1,868	None	
	Fordsville	489	I	No sewers
	Centertown	323		No sewers
	McHenry	420		No sewers
	Rockport	377		No sewers
Pulaski				
Russell				
Simpson	Franklin	6,553	I	Pending
Taylor	Campbellsville	7,598	I	
Todd				
Warren	Smiths Grove	756		No sewers
	Woodburn	351		No sewers
	Bowling Green	36,253	I	
	Bowling Green	36,253	III	STP Only

Table F-9
Continued

County	City	Population	Project Type	Comments
Webster	Sebree	1,092	None	
	Slaughters	276	I	Pending

NOTE: Project type is related to thy type of grant applied for or received by each city. Type I is for preliminary studies necessary before design of the facility. Type II is the design phase of a facility and Type III is for the construction of a facility for the collection and treatment of domestic sewage.

The comments relate to the status of the grant. Underway indicates the project type is funded. Pending indicates that application for a grant has been made and is pending approval and no sewers means when a grant is requested that it is for a complete and original system.

The source of this information was the 1970 U.S. Census and the FY 75 construction grants list for Kentucky.

Table F-10

Water Quality Data for Green River Basin

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	pH Specific Units Kentucky Standard (Ky. Std.) 6 to 9						
Green River, Munfordville	330	7.7	0.4	9.6	6.8	1-61	9-73
	14	7.9	0.1	8.4	7.0	1-73	9-73
Barren R., Bowling Green	40	7.5	0.2	8.2	6.6	10-59	4-74
Pond River, Sacremento	70	4.9	2.0	7.0	2.8	10-59	6-73
Green R., Lock No. 1	33	7.5	0.1	8.1	6.8	10-59	8-72
	Conductivity micro mhos, Ky. Std. 800 micro mhos						
Green R., Munfordville	364	400	240	1,750	47	1-61	9-73
	14	250	70	390	149	1-73	9-73
Barren R., Bowling Green	53	250	40	321	116	10-59	5-74
Pond R., Sacremento	75	1,150	820	3,230	143	10-59	6-73
Green R., Lock No. 1	78	390	180	1,080	154	10-59	8-72
	Dissolved Solids mg/l, Ky. Std. 500 micro mhos						
Green R., Munfordville	355	220	130	1,040	61	1-61	9-73
	14	150	40	216	80	1-73	9-73
Barren R., Bowling Green	15	140	30	177	75	10-59	5-74
Pond R., Sacremento	16	690	670	2,370	124	10-59	6-73
	Alkalinity mg/l, No Standard						
Green R., Munfordville	210	96	25	153	40	10-59	9-73
	14	96	33	141	57	1-73	9-73
Barren R., Bowling Green	33	101	16	141	46	10-59	5-74
Pond R., Sacremento	47	9	13	57	0	10-59	6-73
Green R., Lock No. 1	37	78	21	119	6	10-59	8-72
	Hardness mg/l, 0-60 soft, 61-120 mod. hard, 121-180 hard, over 180 very hard						
Green R., Munfordville	327	130	50	387	45	1-61	9-73
	14	120	30	170	71	1-73	9-73
Barren R., Bowling Green	41	120	20	157	52	10-59	5-74
Pond R., Sacremento	65	480	360	1,540	58	10-59	6-73
Green R., Lock No. 1	70	140	30	225	64	10-59	8-72
	Color Platinum - Cobalt Units, Prop. E.P.A. Std. 75 units						
Green R., Munfordville	250	9	9.6	55	0	10-59	10-72
Barren River, Bowling Green	14	7	9.3	38	0	10-59	3-71
Pond River, Sacremento	48	7	11.0	56	0	10-59	6-73
Green River, Lock No. 1	47	8	8.2	40	1	10-59	4-71

Table F-10
Continued

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	Sodium mg/l, No Standard						
Green River, Munfordville	66	43	41	218	3.5	1-61	10-73
Barren River, Bowling Green	17	4	1.0	5.6	2.1	10-59	5-74
Pond River, Sacremento	37	39	32	139	5.4	10-59	6-73
Green River, Lock No. 1	55	28	28	132	4.2	10-59	4-71
	Potassium mg/l, No Standard						
Green River, Munfordville	20	2.2	1.0	5.2	0.8	11-59	10-72
Barren River, Bowling Green	17	1.4	0.6	2.6	0.5	10-59	5-74
Pond River, Sacremento	37	3.2	1.7	8.5	0.9	10-59	6-73
Green R., Lock No. 1	53	2.0	0.8	4.1	0.9	10-59	4-71
	Chloride mg/l, Prop. E.P.A. Std. 250 mg/l						
Green River, Munfordville	355	54	64	455	3.0	1-61	9-73
	14	12	7.6	30	3.0	1-73	9-73
Barren River, Bowling Green	41	7	1.8	11	3.5	10-59	5-74
Pond River, Sacremento	68	34	45	318	4.5	10-59	6-73
Green River, Lock No. 1	70	40	52	254	5.0	10-59	8-72
	Sulfate mg/l, Prop. E.P.A. Std. 250 mg/l						
Green River, Munfordville	328	18	7.0	106	7.4	1-61	9-73
	14	16	2.3	22	13	1-73	9-73
Barren River, Bowling Green	41	18	5.1	36	8	10-59	5-74
Pond River, Sacremento	69	567	488	1,900	62	10-59	6-73
Green River, Lock No. 1	70	51	22	107	17	10-59	8-72
	Nitrate - N mg/l, Prop. E.P.A. Std. 10 mg/l						
Green River, Munfordville	35	0.9	0.3	1.6	0.4	3-72	9-73
	14	0.9	0.2	1.3	0.6	1-73	9-73
	Fluoride mg/l, Ky. Std. 1.0 mg/l						
Green River, Munfordville	49	0.4	0.3	0.9	0.07	1-70	11-74
	21	0.5	0.3	0.9	0.10	1-73	11-74
Barren River, Bowling Green	51	0.3	0.3	0.9	0.0	5-69	10-74
	19	0.4	0.3	0.9	0.1	1-73	10-74
Green River, Central City	47	0.4	0.3	0.9	0.0	2-70	10-74
	15	0.5	0.3	0.9	0.1	1-73	10-74
Pond River, Sacremento	43	1.0	0.9	3.2	0.0	10-59	6-73
Green River, Lock No. 1	50	0.2	0.1	0.5	0.0	10-59	8-72
	Calcium mg/l, No Standard						
Green River, Munfordville	142	55	40	356	15	10-59	10-72

Table F-10
Continued

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
Barren River, Bowling Green	17	37	7	48	17	10-59	10-72
Pond River, Sacremento	37	92	65	274	18	12-73	10-74
Green River, Lock No. 1	55	40	10	62	20	10-59	4-71
Magnesium mg/1, No Standard							
Green River, Munfordville	142	11.7	10	80	2.5	10-59	10-72
Barren R., Bowling Green	17	6.8	2	12	2.3	10-59	5-74
Pond River, Sacremento	37	42.2	38	158	5.8	10-59	6-73
Green River, Lock No. 1	55	9.3	3	18	3.5		
Cadmium micrograms/liter, Ky. Std. 100 ug/1							
Green R., Munfordville	52	1.9	7.0	5	0	1-70	11-74
	21	0.9	0.4	2	0	2-73	11-74
Barren R., Bowling Green	48	1.1	0.9	5	0	1-70	10-74
	19	1.0	0.5	2	0	7-73	10-74
Green R., Central City	43	1.0	0.7	3	0	2-70	10-74
	15	0.9	0.5	2	0	1-73	10-74
Manganese micrograms/liter, Prop. Ky. Std. 50 ug/1							
Pond River, Sacremento	24	4,930	4,710	17,000	220	10-59	6-73
Iron micrograms/liter, Prop. E.P.A. Std. 300 ug/1							
Green River, Munfordville	14	50	85	330	0	10-65	9-66
Barren River, Bowling Green	14	290	610	2,400	0	10-59	7-72
Pond River, Sacremento	24	1,050	880	3,200	90	10-59	6-73
Chromium micrograms/liter, Ky. Std. 50 ug/1							
Green River, Munfordville	50	1.2	1.2	5	0	1-70	11-74
	14	1.4	1.5	5	0	2-73	11-74
Barren River, Bowling Green	51	0.9	0.9	4	0	5-69	10-74
	15	1.1	0.7	3	0	1-73	10-74
Green R., Central City	45	1.5	1.3	5	0	2-70	10-74
	15	2.3	1.5	5	0	1-73	10-74
Lead micrograms/liter, Ky. Std. 50 ug/1							
Green River, Munfordville	51	53	122	770	1	1-70	11-74
	21	61	84	203	6	1-73	11-74
Barren River, Bowling Green	48	10	9	53	0.3	5-69	10-74
	19	13	7	35	5	1-73	10-74
Green River, Central City	43	15	17	78	0.1	2-70	10-74
	15	19	18	78	6	1-73	10-74

Table F-10
Continued

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	Silver micrograms/liter, Ky. Std. 50 ug/l						
Green River, Munfordville	51	0.73	0.7	3	0	1-70	11-74
	22	0.86	0.3	1	0	1-73	11-74
Barren River, Bowling Green	51	0.75	0.9	3	0	5-69	10-74
	19	0.68	0.5	1	0	1-73	10-74
Green River, Central City	44	0.61	0.5	2	0	2-70	10-74
	15	1.00	0.0	1	1	1-73	10-74
	Arsenic micrograms/liter, Ky. Std. 50 ug/l						
Green River, Munfordville	11	0.45	0.5	1	0	1-71	4-74
Barren River, Bowling Green	14	0.36	0.6	2	0	1-71	4-74
Green River, Central City	14	0.57	0.6	2	0	1-71	4-74
	6	0.33	0.5	1	0	1-73	4-74

#Obs: Total number of observations in period shown

S: Standard Deviation

Table F-11

Organic Loads Affecting Streams in the Green River Basin

Length of streams to which treated organic loads are discharged		1,670
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow with present treatment		214
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to with present treatment	Municipal Discharges	173
	Industrial Discharges	6.8
	Other Discharges	34.5

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q 10-7) low flow.

Table F-12

Water Usage for Industry and the Public in the Green River Basin

County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Adair	Columbia	267,000	2,700		
Allen	Scottsville			456,000	114,000
Barren	Glasgow Res.	867,000			
	Glasgow Creek	1,300,000	229,000		
	Park City			40,000	
Breckinridge	Kingswood			15,000	
Butler	Morgantown	180,000			
	Rochester	27,700	300		
Casey	Liberty	116,000	38,800		
Christian					
Daviess	Whitesville			40,400	
Edmonson	Bee Spring			1,360	
	Edmonson C.W.D.	265,000			
	Brownsville			60,100	
	Mammoth Cave			73,600	
Grayson	Caneyville	22,300	500		
	Leitchfield			279,000	45,400
Green	Gabe	3,500	172,000		
	Greensburg	172,000	43,000		
	Nally Gibson		24,000		
Hancock					
Hardin	Elizabethtown			1,630,000	16,400
	Upton			45,000	5,000
Hart	Horse Cave			525,000	45,700
	Munfordsville	82,100	11,200		
Henderson	Anaconda Alum.		639,000		

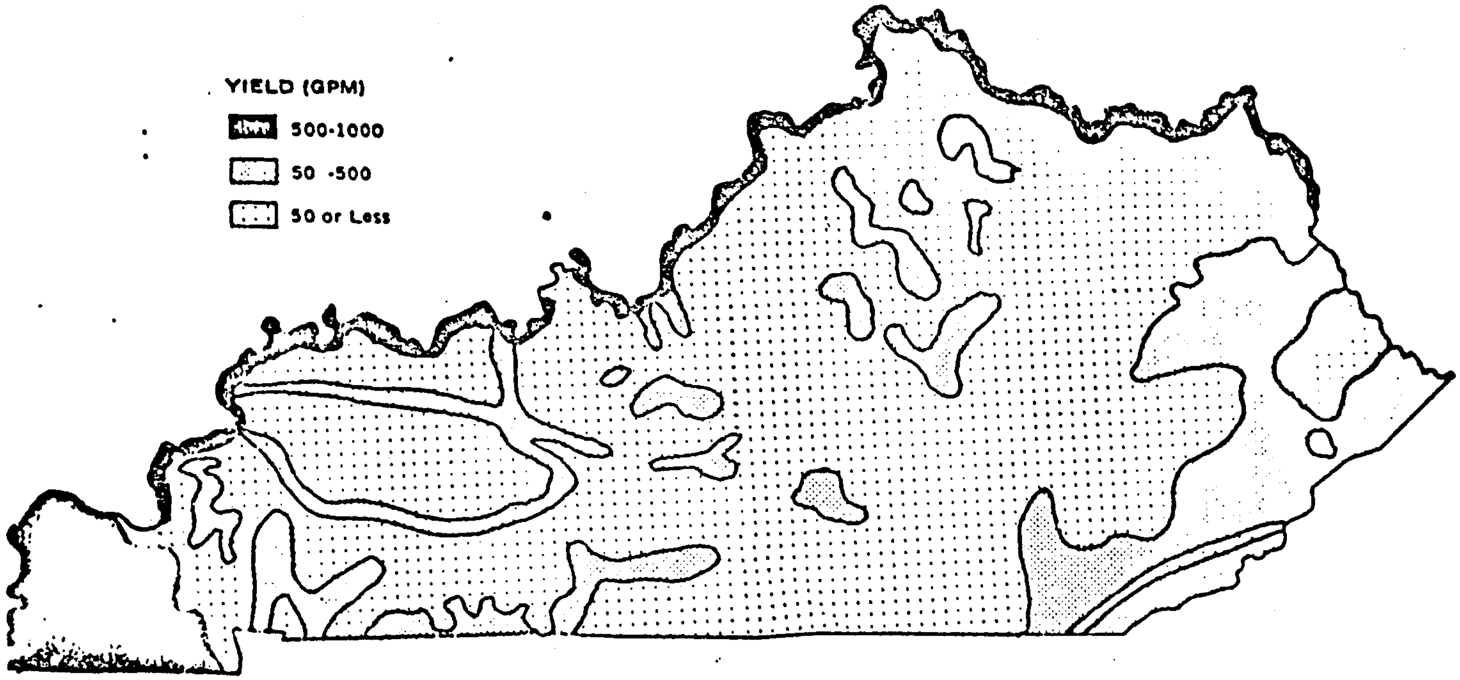
Table F-12
Continued

County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Hopkins	Earlington	148,000			
	Madisonville	1,790,000	268,000		
	Nortonville			75,600	3,900
	White Plains			17,100	900
	Cimmarron Coal		288,000		
	Island Creek Coal		39,800		
Larue	Hodgenville	190,000			
	Auburn Dyeing		12,700		
	Auburn			93,200	23,200
	Caldwell Lace		25,700		
	Lewisburg	43,300	4,800		
	Russellville	436,000	387,000	16,900	14,900
McLean	Calhoun	133,000	133,000		
	Livermore	128,000	14,200		
	Sacramento			19,750	
Metcalfe	Edmonton	48,800	5,400		
Monroe	Gamaliel Res and Creek	49,000			
	Tompkinsville	125,000	75,000		
Muhlenberg	Central City	713,000	75,000		
	Gilbrater Coal		1,520,000		
	Pittsburg Midway		164,000		
	Drakesboro			102,000	1,000
	Graham	17,100	175		
	Greenville	323,000	17,000		
	Kirkpatrick Mine		35,000		
	Wright Coal (Madisonville)		79,400		
	Peabody Coal (Beaver Dam)		739,000		
Ohio	Peabody Coal		469,000		
	Fordsville	48,000			
	Hartford	227,000	12,000		
	Ohio C.W.D.	310,000	77,500		
	Rockport	60,400			
	Peabody Coal (Hartford)		288,000		
	Peabody Coal		590,000		
Pulaski					
Russell					

Table F-12
Continued

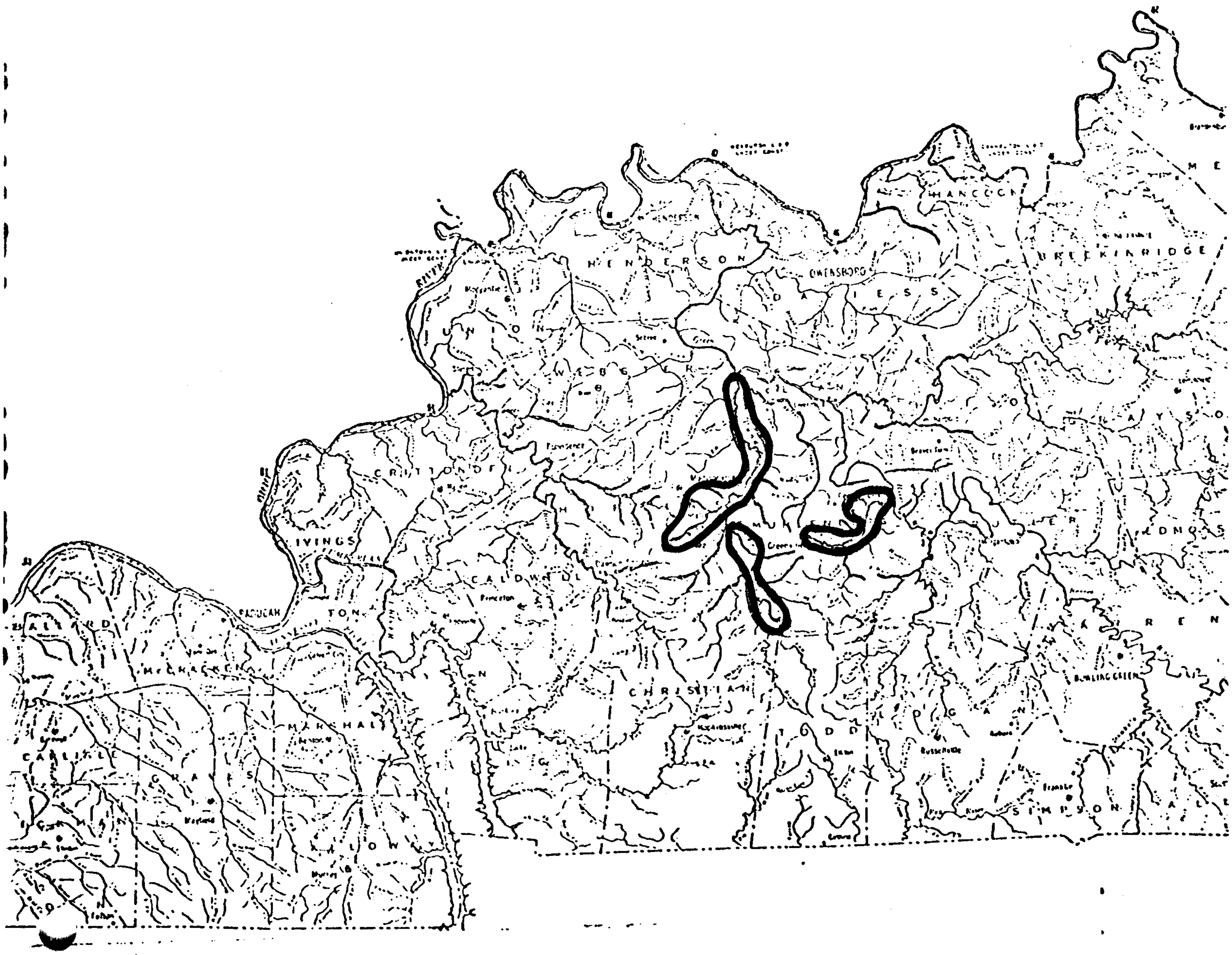
County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Simpson	Franklin	709,000	382,000		
Taylor	Campbellsville Res. and Creek	600,000	900,000		
	Tennessee Gas Piping		183,000	4,000	
Todd					
Warren	Bowling Green	5,230,000	922,000		
	Beech Bend			10,000	
	Warren C.W.D.			131,000	
	Pet Milk				460,000
	Smiths Grove			55,000	600
Webster	Dixon	65,000			
	Sebree			76,000	1,000
	Texas Gas (Slaughters)				44,500
	Slaughters	44,000			
		14,700,000	9,800,000	3,770,000	777,000

Source: Kentucky Department for Natural Resources and Environmental Protection
Division of Water Resources


YIELD (GPM)
500-1000
50 -500
50 or Less

Streams Affected by Mine Drainage

STREAMS CONTINUOUSLY OR SIGNIFICANTLY AFFECTED



THE SALT RIVER BASIN

The Salt River Basin is the most centrally located basin in Kentucky. It extends 70 miles into Kentucky through rolling farmland and is as wide as it is long. The water quality in this basin is influenced by dry season low flow, excessive erosion, and by the largest population center in Kentucky, Louisville, being partly located within this basin.

The first section of this report will provide a basin description covering both physical and population characteristics. The second section will analyze the water quality considering its causes and effects.

I. Basin Description

A. Geography

The Salt River flows into the Ohio River 352 miles above the mouth of of the Ohio River. The city of West Point at the mouth of the Salt River is 23 miles downstream of Louisville.

The Salt River drains 2,932 square miles of rolling farmland in central Kentucky. This drainage basin contains all or part of the following counties: Bullitt, Jefferson, Oldham, Henry, Shelby, Anderson, Mercer, Boyle, Casey, Marion, Taylor, Larue, Hardin, Nelson, Washington, and Spencer. In the Salt River Basin, there are five sub-basins with an area over 200 square miles. Beech Fork has approximately 750 square miles, Brashears Creek, Floyds Fork, and the Chaplin River all drain about 270 square miles, and the Rolling Fork drains 145 square miles.

B. Topography

The basin lies wholly within the Bluegrass Region which has a hilly to gently rolling topography from east to west with an area of "Knobs" in the northwestern section around the Fort Knox military reservation. This basin is drained by three major streams. These are the Salt River, the Rolling Fork and Beach Fork. The slope of the Salt River is 5.0 feet per mile (ft./mi.).

The slope of Rolling Fork averages 6 ft./mi. and the slope of the Beach Fork is 4 ft./mi.

The average slope of the major tributaries are Brashears Creek, 6 ft./mi., Chaplin River, 6.5 ft./mi., and Floyds Fork, 7 ft./mi. The elevation in this basin varies from 380 to 1,140 feet above sea level.

Slope, up to ten ft./mi., has a direct effect on the reaeration of a stream. With slopes from 0-2 ft./mi., the reaeration is low. Slopes from 3-6 ft./mi. give a medium reaeration while slopes of 7-10 ft./mi. give a high reaeration. These stream slopes provide moderate to good reaeration of the streams.

C. Geology

The base parent materials in this basin are limestone and dolomite, slate and shale. The limestone and dolomite through solution impart hardness to water and give rise to a bicarbonate type of hardness.

The groundwater availability in the Salt River Basin is low. Wells which yeild 100 gallons per minute (g.p.m.) are rare, the majority of the wells produce 50 g.p.m. or less. This limited availability of groundwater and the "Knob" topography are factors causing extremely low flow during the dry months of the year.

D. Hydrology

The stream flow in the Salt River Basin was selected at four gauging stations. The stations are (1) at Boston on the Rolling Fork, (2) at Bardstown on the Beach Fork, (3) Fisherville on Floyds Fork, and (4) at Shepherdsville on the Salt River.

For these stations, the period of record, drainage area, average flow, maximum flow, minimum flow, and the seven day ten year low flows as follows:

Surface Flow Records for the Salt River Basin

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 day 10 yr. Low Flow
Salt River at Shepherdsville, Kentucky	36 yr.	1,197 sq. mi.	1,516 cfs, 1.3 cfs*/sq. mi.	78,200 cfs, 65 cfs/sq. mi.	0 cfs, 0 cfs/sq. mi.	0.6 cfs**
Floyds Fork of Salt River at Fisherville, Kentucky	30 yr.	138 sq. mi.	168 cfs, 1.2 cfs/sq. mi.	28,500 cfs, 206 cfs/sq. mi.	0 cfs, 0 cfs/sq. mi.	0 cfs
Rolling Fork of Salt River at Boston, Kentucky	36 yr.	1,299 sq. mi.	1,705 cfs, 1.3 cfs/sq. mi.	50,500 cfs, 38.9 cfs/sq. mi.	0.4 cfs, 0 cfs/sq. mi.	1.7 cfs
Beech Fork of Salt River at Bardstown, Kentucky	35 yr.	669 sq. mi.	894 cfs, 1.3 cfs/sq. mi.	33,900 cfs, 50.7 cfs/sq. mi.	0 cfs, 0 cfs/sq. mi.	0.2 cfs

* Cubic Feet Per Second

** Extrapolated

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

Presently, there are no major impoundages in the Salt River to provide for low flow augmentation. The Corps of Engineers has been authorized to construct the Taylorsville Reservoir which will provide low flow augmentation of 60 cfs.

The Salt River at Shepherdsville is very flashy as shown in comparison of the average flow to the maximum. The ratio of average to maximum is 52. Most of the streams at some time of the year have zero flow. The low flow contributes to problems with organic waste loads and sediment.

E. Population

There are 507,232 people in this basin (see Table G-2). The SMSA of Louisville accounts for sixty-four per cent of the population. This portion of Louisville (Jefferson County) is located in the Pond Creek and Floyds Fork Sub-basins. Louisville has completed a 201 Facility Plan and is developing a 208 area wide waste water management plan. As the 201 plan is implemented, the effect of the 250 discharge into Pond Creek and Floyds Fork will be eliminated with the initial interceptors planned for completion in 1977 and all discharges eliminated by 1985. Roughly seven per cent of the population is located in Hardin County at Fort Knox. The rest of the population is located in small towns and rural populaton throughout the basin. There are eight towns (13,679 people who do not have sewers and these represent possible sources of pollution from septic tanks and other inadequate treatment devices.

II. Basin Water Quality

In this section of the report the actual water quality in the Salt River Basin will be examined, along with some of the major factors involved. The major water uses in the basin are also presented.

A. A Description of Sampling Stations

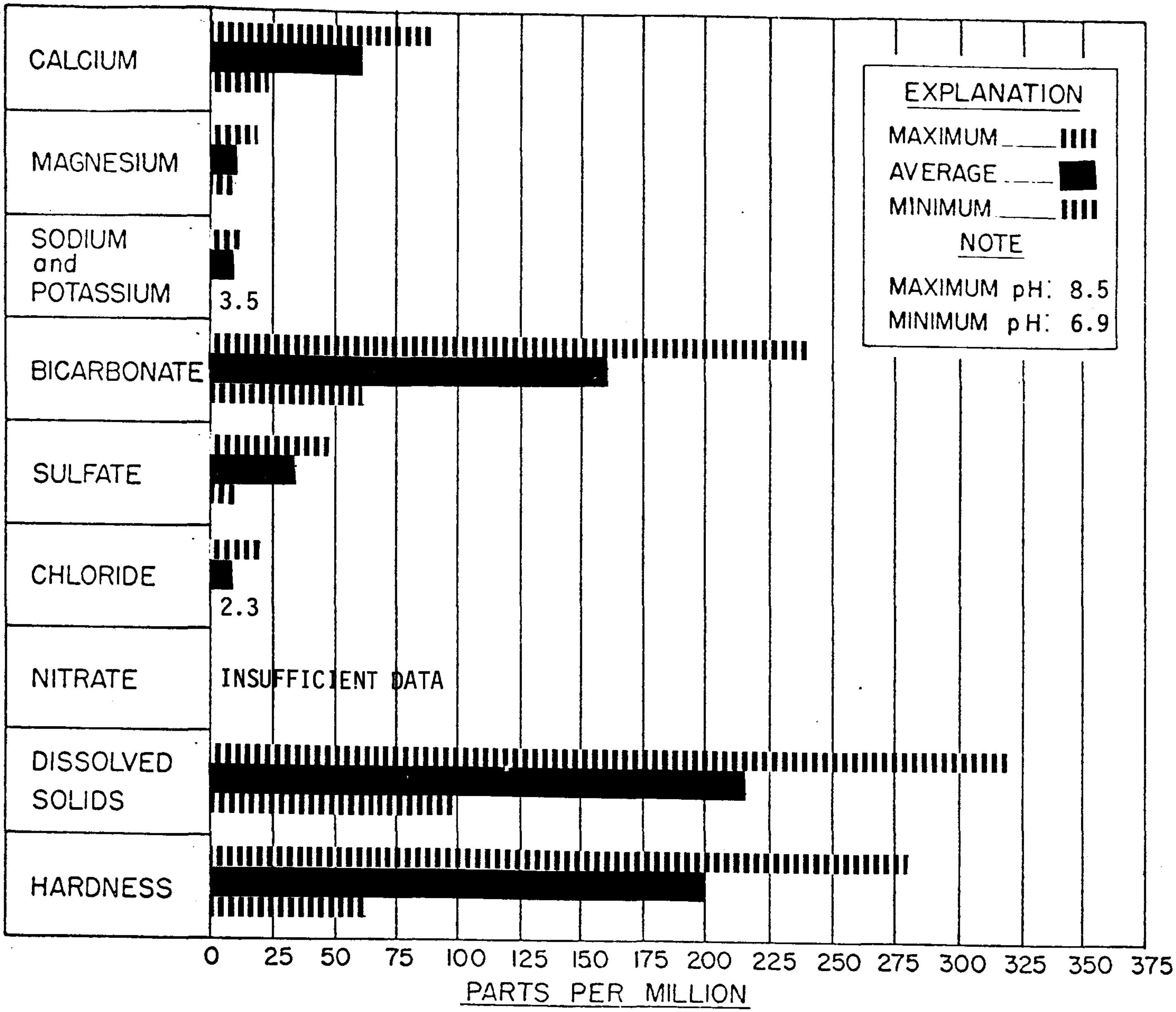
There is only one station in this basin with sufficient data to describe water quality. It is located at Shepherdsville, Kentucky, 23 miles upstream from the mouth of the Salt River with drainage basin area of 1,200 sq. mi. or 41 per cent of the basin.

This station was chosen due to the location and length of record. It is believed that the water quality measured at this station is representative of the water quality in most of the surface streams in the basin.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

In the Salt River Basin, there is a high bicarbonate ion content giving the water a high bicarbonate hardness. This is due to the limestone bedrock of the area. In all other respects the quality of the surface water is considered to be excellent. The graph of water quality indicates the variation from the



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents, Salt River at Shepherdsville

Period of Record: 11-65 to 11-74

FIGURE G-1

average is low and, therefore, uniformity of water quality allows stable operation of water supply treatment plant and industry water usage is enhanced.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the Salt River Basin in Kentucky were measured as being within Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemical degradable waste impost a load on the dissolved oxygen recourses of a stream. Such a waste load is considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 596 miles of streams in the basin that receive waste discharges were evaluated.. On the basis of present treatment levels and once on 10 year 7 day low flows the model shows 166 stream miles (28 per cent of the miles modeled) are affected by discharges.

The types of facilities affecting the streams and the length affected are 67 miles (11.2 per cent) by municipal discharges; 9.5 miles (1.7 per cent) by industrial discharges, and 89.5 miles (15 per cent) by other discharges. A miscellaneous discharge is one that is privately owned, eg. subdivisions, schools, etc. (See Table G-5)

E. Non-Point Source Effects

The primary non-point source of pollution in the Salt River is from soil erosion. The sediment pollution comes from field and stream bank erosion. In 1973 about 100 sq. mi. associated with agricultural crop land had high erosion rates and there are approximately 50 miles of streambanks that is a critical sediment source.

F. Water Uses in the Basin

Water uses in the basin are public and industrial, recreation, fish and wildlife, and agricultural. The total public and industrial usage in the Salt River Basin is 10 million gallons per day (m.g.d.) from surface water at 9.6 m.g.d. and groundwater at 0.4 m.g.d. The industrial usage is 5.5 m.g.d., (groundwater 0.1 m.g.d., surface water 5.4 m.g.d.) and the public usage is 4.5 m.g.d., (groundwater 0.4 m.g.d. and surface water 4.1 m.g.d.). Water withdrawal during periods of low flow is not a problem since during periods of low flow the water is withdrawn from reservoirs.

There are no large commercial water recreation sites in this basin.

It is generally understood that the Salt River Basin is good in sport fishing.

The Kentucky Department of Fish and Wildlife Resources is studying the sport fishing in this basin and a report will be published in the next two years.

G. Water Quality Changes

Sedimentation data that was collected in the period of 1948 to 1954 indicated that the Salt River Basin had the largest sediment load than any basin in Kentucky. The effects of agricultural runoff and logging operations in relation to the topography created a difficult control problem from these sources of sediment load. Continued effort by the U.S.D.A. SCS by encouraging proper soil utilization should assist in controlling the sediment load problem.

The problem associated with municipal waste discharge into Pond Creek and Floyds Fork will be corrected in a comparatively short time by intercepting the waste and conveying this waste to a treatment facility to be located on the Ohio River. Therefore, the expected changes in water quality are for improvement in both sediment load and from maintenance of D.O. levels at or above the level of the State-Federal Water Quality Standards.

III. Summary

The general chemical and trace water quality in Kentucky's Salt River Basin has been shown to be of high quality. There are problems, however, related to other aspects of water quality in the basin that require attention and action to be corrected. Severe soil erosion from farming practices presents a major problem with excessive sediment in the water. Treated wastes discharged from municipal, independent and industrial sources effect the water quality of the basin's streams. Upgrading the treatment facility and improvement in operation and maintenance of waste treatment facilities is needed. A program of operator licensing and education to improve operation and maintenance is a significant part of the Division of Water Quality operations.

TABLE G-2

Population in the Salt River Basin

County	City		Urban Population in Basin	Total Population in Basin	Area (sq. mi.)
Casey				4,150	94
Taylor				100	28
Larue				2,600	89
Hardin				49,000	140
	Fort Knox		37,608		
	Radcliff		7,881		
		Total	45,489		
Bullitt				26,090	300
	Mt. Washington		2,020		
Jefferson				323,000	220
	Louisville		79,919		
	Seneca Gardens		822		
	Strathmore		1,004		
	Jeffersontown		9,701		
	Fern Creek		6,000		
	Beuchel		9,000		
	Audubon Park		1,862		
	Newburg		4,000		
	Okolona		17,643		
	Prairie Village		3,000		
	Fairdale		2,500		
	Glengary		1,500		
	Valley		3,500		
	Medora		300		
		Total	166,882		
Oldham				5,750	64
	Crestwood		900		
	Pewee Valley		950		
			1,850		
Henry				1,087	14
	Pleasureville		747		
Shelby				15,900	314
	Shelbyville		4,182		
	Simpsonville		628		
	Veachland		700		
		Total	5,510		
Anderson				7,500	140
	Lawrenceburg		3,579		
	Stringtown		300		
			3,879		
Mercer				11,800	150
	Harrodsburg		6,741		
	Salvisa		350		
			7,091		

County	City		Urban Population in Basin	Total Population in Basin	Area (sq. mi.)
Boyle				4,600	100
	Mitchellsburg		500		
	Perryville		730		
		Total	1,230		
Marion	Bradfordsville		338	16,700	343
Nelson				23,480	437
	New Haven		977		
	Bardstown		5,816		
		Total	6,793		
Washington				10,730	307
	Loretto		985		
	Springfield		2,961		
			3,946		
Spencer				5,492	192
	Taylorsville		897		
		TOTAL	245,925	507,232	2,932

Source: 1970 U. S. Census as reported in the Rand McNally "Standard Reference Map and Guide of Kentucky"

TABLE G-3

Water Quality Data in the Salt River Basin
Data Presented was collected on the Salt River at Shepherdsville

Parameter	#Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
1) pH specific units, Kentucky Standard is 6-9							
	39	7.8	0.5	8.5	6.9	11-65	4-74
2) Conductivity micro mhos, Kentucky Standard 800 micro mhos							
	49	400	80	540	170	11-65	6-74
3) Dissolved Solids mg/l (milligrams per liter), Kentucky Standard, 500 mg/l							
	5	210	100	320	98	3-69	4-74
4) Alkalinity mg/l, no standard							
	19	160	44	240	62	10-66	4-74
5) Hardness mg/l, 0-60 soft, 61-120 mod. hard, 121-180 hard, 181+ very hard							
	39	200	51	280	62	11-65	4-74
6) Fluoride mg/l, Kentucky Standard 1.0 mg/l							
	56	0.2	0.2	0.9	0.1	1-70	11-74
	22	0.3	0.3	0.9	0.1	1-73	11-74
7) Calcium mg/l, no standard							
	7	60	26	90	23	11-65	4-74
8) Magnesium mg/l, no standard							
	7	11	6.3	18	1.0	11-65	4-74
9) Lead ug/l, Kentucky Standard 50 micro-grams per liter (ug/l)							
	54	13	6	34	0	1-70	11-74
	22	14	5	25	0	1-73	11-74
10) Silver ug/l, Kentucky Standard 50 ug/l							
	54	0.78	0.5	2.0	0	1-70	11-74
	22	0.77	0.4	1.0	0	1-73	11-74
11) Arsenic ug/l, Kentucky Standard 50 ug/l							
	14	0.64	0.9	3.0	0	1-70	4-74
	6	0.33	0.5	1.0	0	1-73	4-74
12) Cadminum ug/l, Kentucky Standard 100 ug/l							
	55	1.2	0.8	4.0	0	1-70	11-74
	22	1.2	1.1	4.0	0	1-73	11-74
13) Chromium ug/l, Kentucky Standard 50 ug/l							
	55	1.4	1.2	5.0	0	1-70	11-74
	22	2.0	1.1	5.0	0	1-73	11-74

TABLE G-3
Page #2

Water Quality Date in the Salt River Basin
Data Presented was collected on the Salt River at Shepherdsville

		#Obs.	Mean	Standard Deviation	Max.	Min.	Beginning Date	Ending Date
15)	Color	Platinum Cobalt Units						
		7	29	50	140	1	11-65	4-74
16)	Sodium	mg/l, no standard						
		7	6.1	2.1	8.9	2.0	11-65	4-74
		6	5.2	1.7	7.9	3.3	4-73	10-74
17)	Potassium	mg/l, no standard						
		7	2.6	.72	3.7	1.5	11-65	4-74
18)	Chloride	mg/l, prop. EPA Standard 250 mg/l						
		39	8.3	2.9	19	2.3	11-65	4-74
19)	Sulfate	mg/l, prop. EPA Standard 250 mg/l						
		39	34	9.0	48	10	11-65	4-74

TABLE G-4

Construction Grants in the Salt River Basin

COUNTY-CITY	POPULATION	TYPE OF GRANT	COMMENTS
Anderson			
Alton	160	II	Pending
Lawrenceburg	3,579	I	Underway
Bullitt			
Lebanon Junction	1,571	I	Pending
Henry			
Pleasureville	747	I	Pending
Jefferson			
Jeffersontown	9,701	I	Pending
Okolona	17,643	I	Pending
Marion			
Lebanon	5,528	I	Pending
Mercer			
Harrodsburg	6,741	I	Pending
Nelson			
Bardstown	5,816	I	Underway
Shelby			
Shelbyville	4,182	I	Underway
Simpsonville	628	I	Underway
Washington			
Springfield	2,761	I	Underway

NOTE: Project type is related to the type of grant applied for or received by each city. Type I is for preliminary studies necessary before design of the facility. Type II is the design phase of a facility and Type III is for the construction of a facility for the collection and treatment of domestic sewage.

The comments relate to the status of the grant. Underway indicates the project type is funded. Pending indicates that application for a grant has been made and is pending approval and no sewers means when a grant is requested that it is for a complete and original system.

The source of this information was the 1970 U. S. Census and the FY 75 construction grants list for Kentucky.

TABLE G-5

Organic Loads Affecting Streams in the Salt River Basin

Length of streams to which treated organic loads are discharges		596 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		166 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		
	Municipal Discharges	67 miles
	Industrial Discharges	9.5 miles
	Other Discharges	90 miles

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q_{10}-7) low flow.

THE KENTUCKY RIVER BASIN

This report is basically divided into two main sections, the first section being a description of the basin and the second section dealing with the quality of the water in the basin.

The first section is entitled "Basin Description" and describes the geography, topography, geology, hydrology and population characteristics within the Kentucky River Basin.

The second section of the report is entitled "Basin Water Quality" and describes the quality of the water with respect to general chemical, trace chemical, waste load effects, non-point source effects, uses, and changes.

I. A Description of the Kentucky River Basin

A. Geography

In an effort to better describe the Kentucky River Basin it will be divided into two sections. The first section (hereinafter referred to as the "Headwater Section") begins at the headwaters and ends at the City of Irvine and includes the three major forks of the river and 37 miles of its main stem. The remainder of the basin (hereinafter referred to as the "Bluegrass Section") will further be divided into inner and outer sections. The main stem of the Kentucky River is 255.5 miles long from it's mouth to the confluence of the North, Middle and South Forks.

The Kentucky River Basin lies wholly within the State of Kentucky and the river flows in a northwesterly direction. It begins in southeastern Kentucky, flows through the central part of the state and empties into the Ohio River at mile point 435.6 in North Central Kentucky.

The total area of the basin is 7,033 sq. mi. and contains eight sub-basins with areas of over two hundred sq. mi. (See Table H-1) The basin contains, either wholly or partially, 36 of the 120 counties in the State. (See Table H-2)

B. Topography

The Headwater Section is a mountainous area and is heavily mined for coal. Therefore, the water has a considerable sulfate content and is slightly acidic in the immediate coal mining areas. The average slope of the tributaries in this section ranges from 3 ft./mi. to 7.2 ft./mi. which are moderate slopes and it can therefore be said that the waste load assimulation capacity of the tributaries in this section is moderate. The average slope of the main stem of the river in this section is approximately 0.9 ft./mi. which is a low slope for reaeration.

The maximum elevations of the tributaries in this section range from 760 feet to 1,250 feet mean sea level (m.s.l.). It should be noted that water will hold about 2 per cent less dissolved oxygen for every 500 feet in elevation above sea level. Therefore, the dissolved oxygen capacity of these streams is retarded by approximately 4 per cent.

The Bluegrass Section lies in north-central Kentucky and is a structurally high but physiographically level area. The average slope of the tributaries in this section ranges from approximately 3 feet per mile to 32 feet per mile which are moderate to high and it can therefore be said that the waste load assimilation capacity of the tributaries in this section are moderate to high. The average slope of the main stem of the river in this section is approximately 0.7 ft./mi.

The maximum elevations of the tributaries in this section range from 710 feet to 950 feet m.s.l. and therefore the dissolved oxygen capacity of these streams is retarded by approximately 3 per cent. (For more detailed information regarding slopes and elevations see Table H-3)

C. Geology

For the purposes of this report the most significant geological feature in the Headwater Section is the coal resources. Due to the mining activities including the stripping, washing, and loading of coal, there is a great amount of exposed coal in this area. The runoff is rapid and carries a considerable amount of solids to the streams. There are also thin beds of limestone in this area which contribute to the hardness of the water. Because of greater relief and the resulting more rapid runoff of surface water and drainage of groundwater from exposed strata, groundwater is not available in adequate amounts for water supply. Groundwater supplies diminish in dry weather owing to the paucity of groundwater storage.

The Bluegrass Section can be divided into inner and outer sections with regards to geology, the inner bluegrass being underlain by thick, pure limestone and the outer bluegrass by outward dipping thin beds of limestone and shale. The limestone of the inner bluegrass, though thick and soluble, contains shaly zones which are important because they limit the circulation of water and the development of permeable zones. In the outer bluegrass the conditions are even less favorable because the limestone beds are thinner and there is more inner bedded shale. Limestone that underlies shale will rarely yield much water except near streams that have cut through the shale. The only wells in bedrock that produce more than 100 gallons per minute are in thick limestone in the inner bluegrass. Nearly all successful wells in bedrock are less than 100 feet deep. In the bluegrass region as a whole the groundwater is hard to very hard. About one-eighth of the existing wells are reported to yield water containing excessive sodium and chloride, and about one-fifth yield water containing noticeable amounts of hydrogen sulfide.

D. Hydrology

The Kentucky River has fourteen dams (See Table H-8) in it which restrict the flow and cause a decrease in reaeration rates, therefore causing the dissolved oxygen content to be reduced when an organic load is imposed on the stream. Furthermore, the slow moving water allows suspended solids to settle causing sludge deposits which impose a demand on dissolved oxygen and can hamper navigation unless removed.

There are two water withdrawals in the basin that are significant to water quality. The City of Lexington withdraws from the Kentucky River but discharges to tributaries which enter the river below Lock 8, and the City of Winchester withdraws from the Kentucky River but discharges to another basin. The City of Winchester withdraws approximately 1.5 MGD and the City of Lexington withdraws approximately 28 MGD. These two withdrawals are not put back in the river above Lock 8 near Frankfort and therefore reduce the once in seven day, ten year low flow at the Lock by the total 29,500,000 gallons per day or approximately by 20 per cent. This reduced low flow can affect the waste load allocation and subsequent treatment levels required for the cities of Richmond and Berea.

The City of Lawrenceburg also withdraws from the Kentucky River and discharges into another basin but this withdrawal has no significant impact on water quality.

The average normal flow of the Kentucky River at Locks 14, 10, and 4 are 3,583 cubic feet per second, 5,234 cubic feet per second, and 7,042 cubic feet per second respectively. The average yield of the basin is 1.33 cubic feet per second per square mile throughout the main stem of the river. The following table expands on these flow characteristics:

Table H-4

Surface Water Records for the Kentucky River Basin

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 day 10 yr. Low Flow
N. Fork of Ky. River at Hazard	34 yr.	466 sq. mi.	572 cfs, 1.2 cfs* / sq. mi.	47,800 cfs, 103 cfs / sq. mi.	Not Determined	93 cfs
Lock 14 near Heidelberg	42 yr.	2,657 sq. mi.	3,853 cfs, 1.4 cfs / sq. mi.	120,000 cfs, 45 cfs / sq. mi.	4.0 cfs, 0 cfs / sq. mi.	178 cfs
Lock 10 near Winchester	67 yr.	3,955 sq. mi.	5,233 cfs, 1.3 cfs / sq. mi.	92,400 cfs, 23 cfs / sq. mi.	10.0 cfs, 0 cfs / sq. mi.	181 cfs
Lock 4 near Frankfort	49 yr.	5,412 sq. mi.	7,042 cfs, 1.3 cfs / sq. mi.	115,000 cfs, 21 cfs / sq. mi.	Not Determined	281 cfs
Elkhorn Creek near Frankfort	37 yr.	473 sq. mi.	604 cfs, 1.3 cfs / sq. mi.	23, 200 cfs, 49 cfs / sq. mi.	0 cfs, 0 cfs / sq. mi.	28*cfs

* Cubic Feet Per Second

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7 day 10 year low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process. *from effluent from main Lexington Town Branch Plant 18 MGD (28 cfs)

There are fifteen lakes (See Table H-5) located in this basin with a total combined volume of 286,000 acre feet and a total combined surface are of 6,530 acres. The only lakes considered in the Kentucky basin report are those whose volume is greater than 1,000 acre feet or have a surface area greater than 100 acres. Two of these lakes, Buckhorn Lake and Carr Fork Lake, are Federal installations with a combined volume of 28,000 acre feet. The Buckhorn Lake (22,000 acre feet) is regulated to meet flood, recreation, fish and wildlife and low flow augmentation objectives. The low flow augmentation objective aides the stream below the lake during periods of low flow by means of dilution and reaeration. The Carr Fork Lake (6,000 acre feet) has not been in operation long enough to determine its effects upon the stream below it.

E. Population

The total population in the basin is 534,400 with the rural population being 291,200 or 55 per cent of the total population. There are forty-two incorporated cities in the basin representing the remaining 243,200 people. The major concentration of population is in the inner bluegrass region in the adjoining counties of Fayette, Madison, Franklin, Scott and Woodford. These five counties represent 283,900 people or 53 per cent of the total population in the basin. (See Table H-6)

II. Basin Water Quality

A. Description of Sampling Stations

The water quality data presented in the next two sections of this report was collected at five sampling stations. Two of these stations are located on the main stem of the river at Lock 4 near Frankfort and at the Lexington water treatment plant near I-75 in southern Fayette County. The other three stations are located on major tributaries thusly: North Fork of the Kentucky River at Hazard, Red River at Pine Ridge, and Eagle Creek at Glencoe. The total drainage area encompassed by these stations is 5,412 square miles with the station on the North Fork of the Kentucky River at Hazard having 466 square miles above it, the station on the Red River having 180 square miles above it, the station on the main stem at Lexington having 4,015 square miles above it, the station on Eagle Creek at Glencoe having 430 square miles above it, and the station on the main stem at Lock 4 having 5,412 square miles above it. The summary of the raw water quality data is in Table H-9.

The station on the North Fork at Hazard was purposely chosen to represent water quality data in a coal mining area. The other four stations are more indicative of the general water quality in the Kentucky River Basin.

B. General Chemical Water Quality

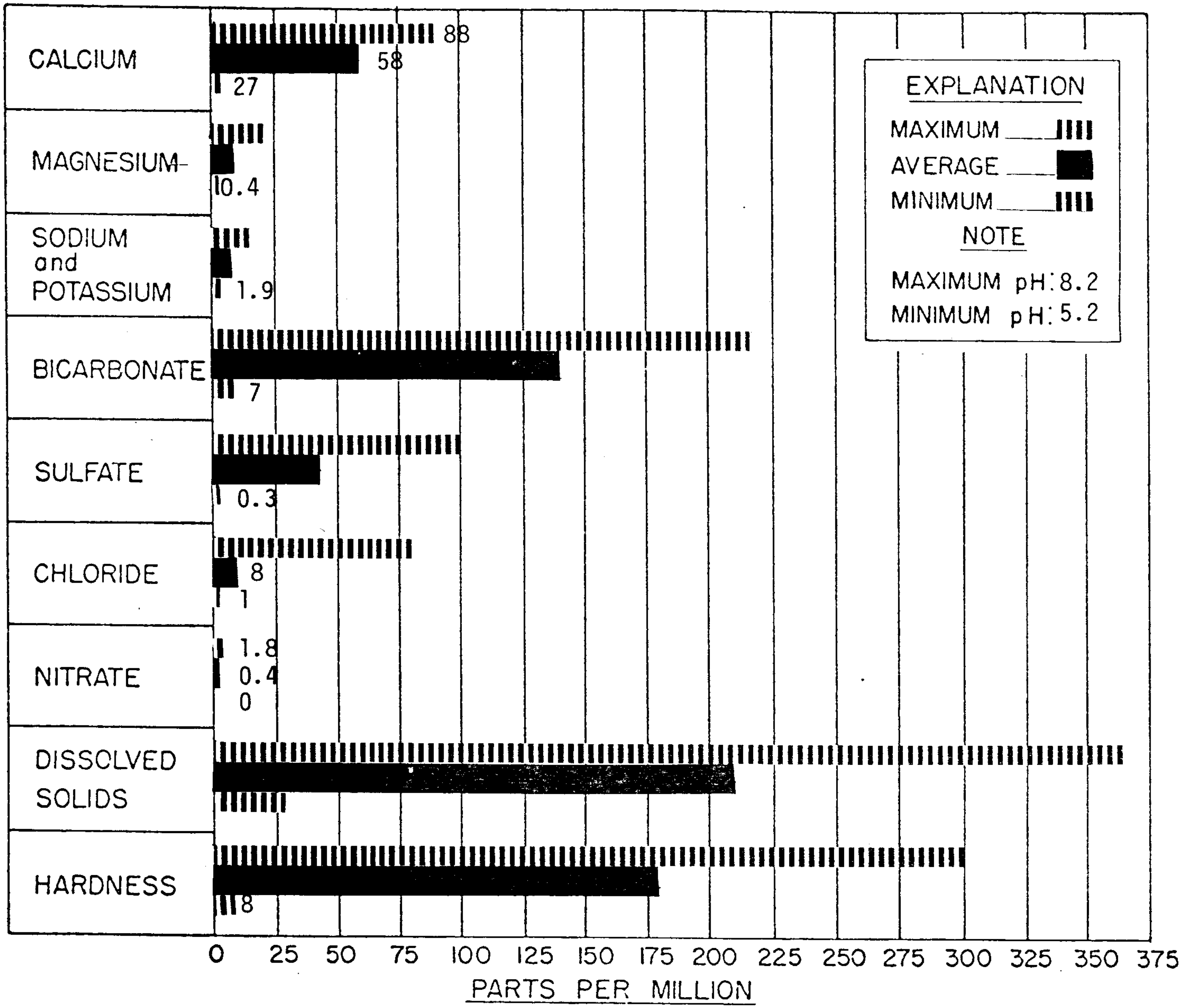
The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 - 25 parts per million as an average value.

The overall water quality for the Kentucky River Basin is represented by the stations at Lock 4 near Frankfort, Red River at Pine Ridge, and Eagle Creek at Glencoe. The two remote stations in the basin are Eagle Creek at Glencoe and the Red River at Pine Ridge and both demonstrate the water quality for a sensitive stream. This means that water quality parameters have a wide range with respect to the average value.

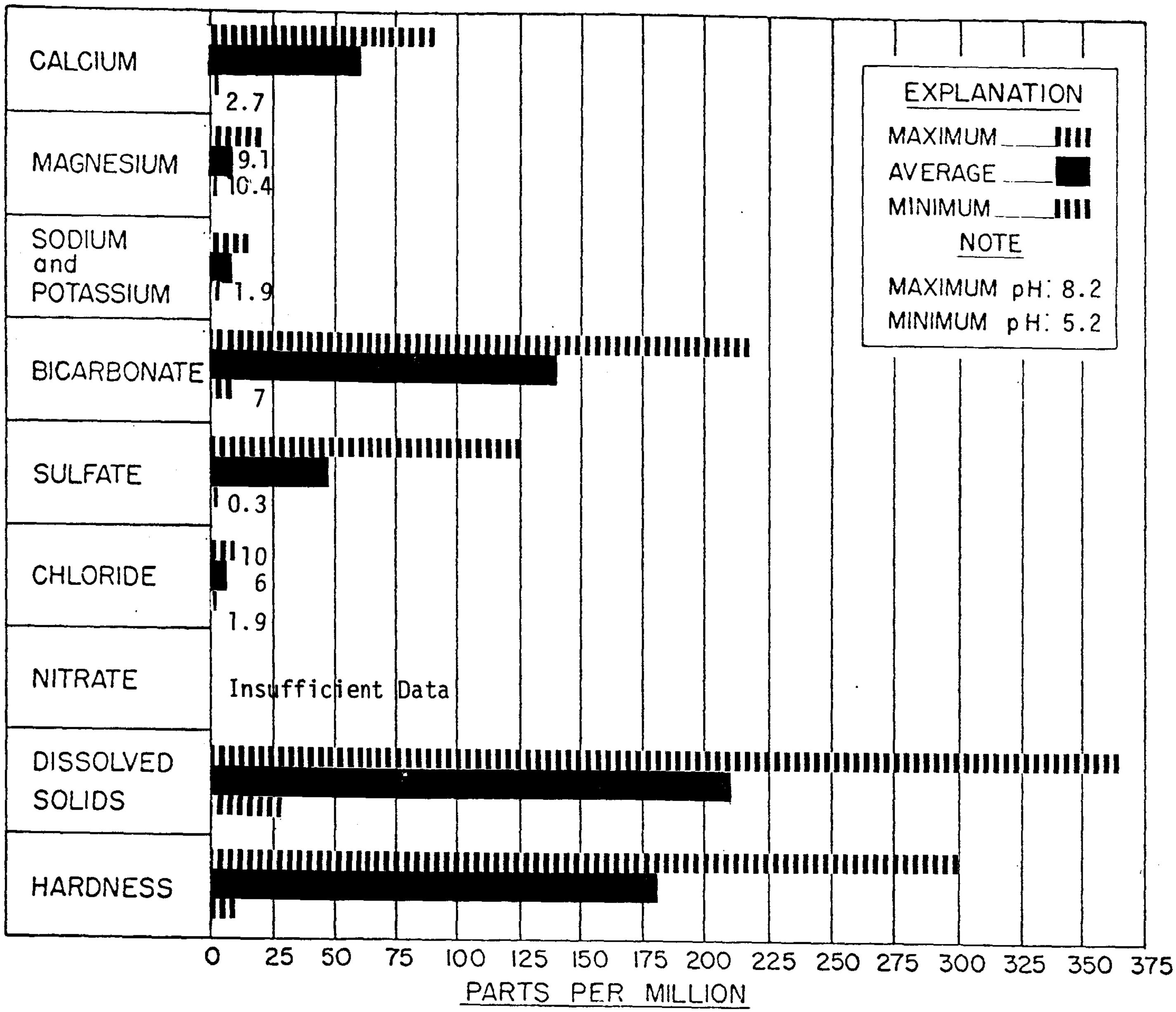
Reference is made to Figures H-1 and H-2 which represent data for Eagle Creek at Glencoe for the period of record and for data collected since January 1, 1973, respectively. Water quality at Eagle Creek at Glencoe indicates that the water is very hard meaning that the calcium carbonate hardness is greater than 180 mg/l. Water in this sub-basin tends to be periodically acidic. The data indicates that the bicarbonate alkalinity is high providing a good inorganic load buffering capacity in this particular stream. The overall water quality in this sub-basin is good.

Relative to the Eagle Creek basin, the water quality in the Red River at Pine Ridge has a higher quality as demonstrated by Figures H-3 and H-4. This is indicated by water characterized as soft (calcium carbonate hardness



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,
Eagle Creek at Glencoe
Period of Record 1-62 to 11-74

Figure H-1

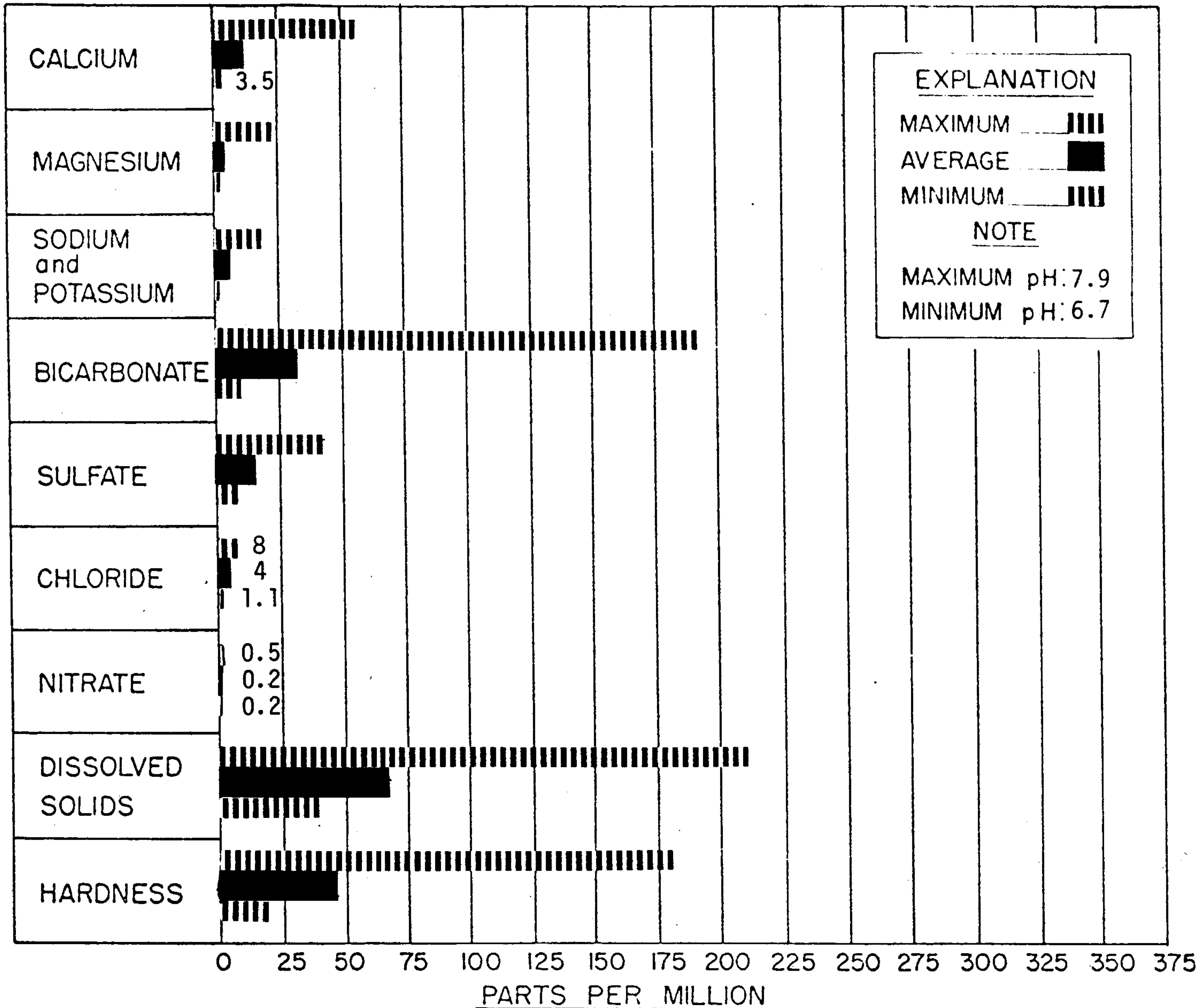


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Eagle Creek at Glencoe

Period of Record 2-73 to 11-74

Figure H-2

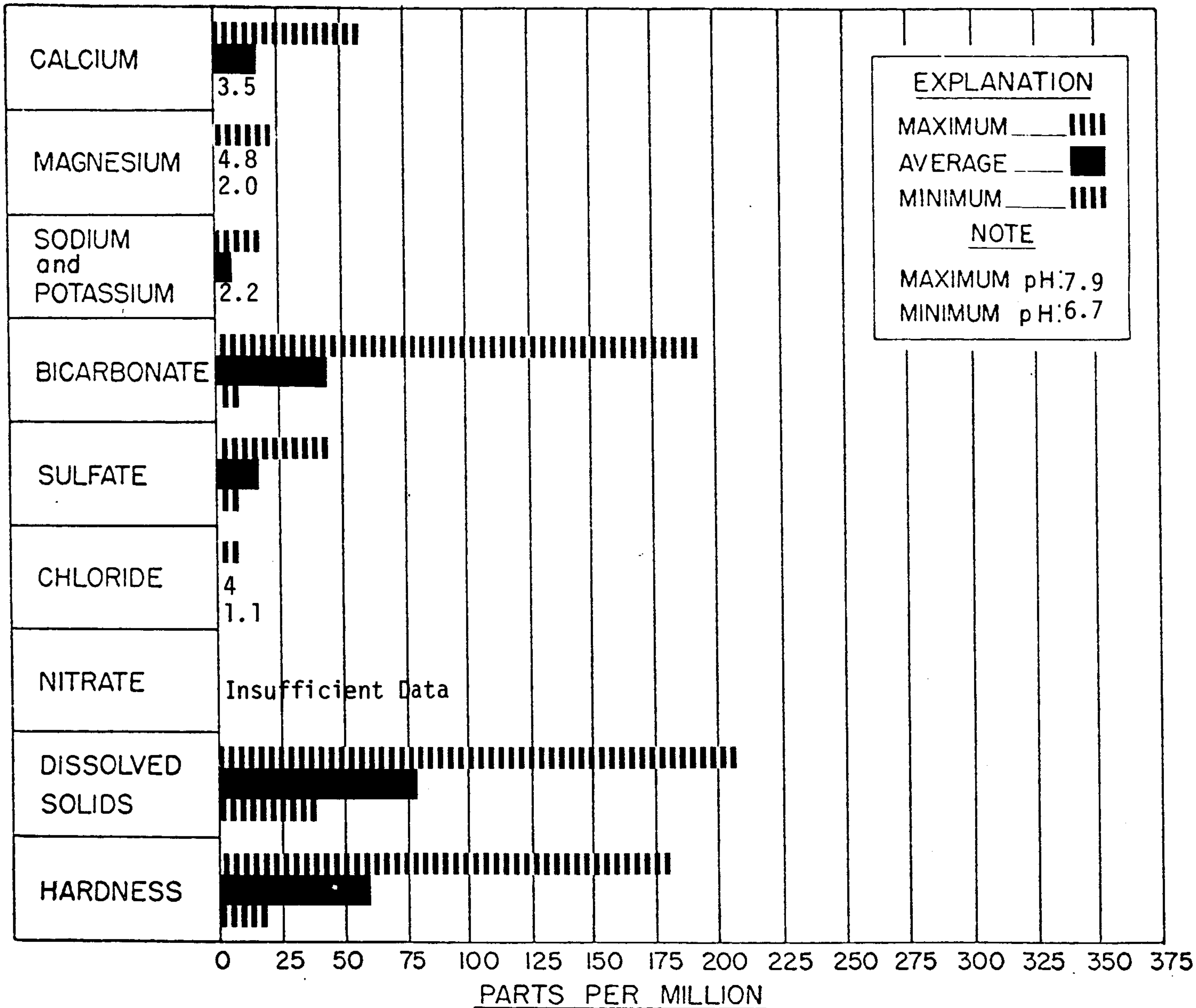


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

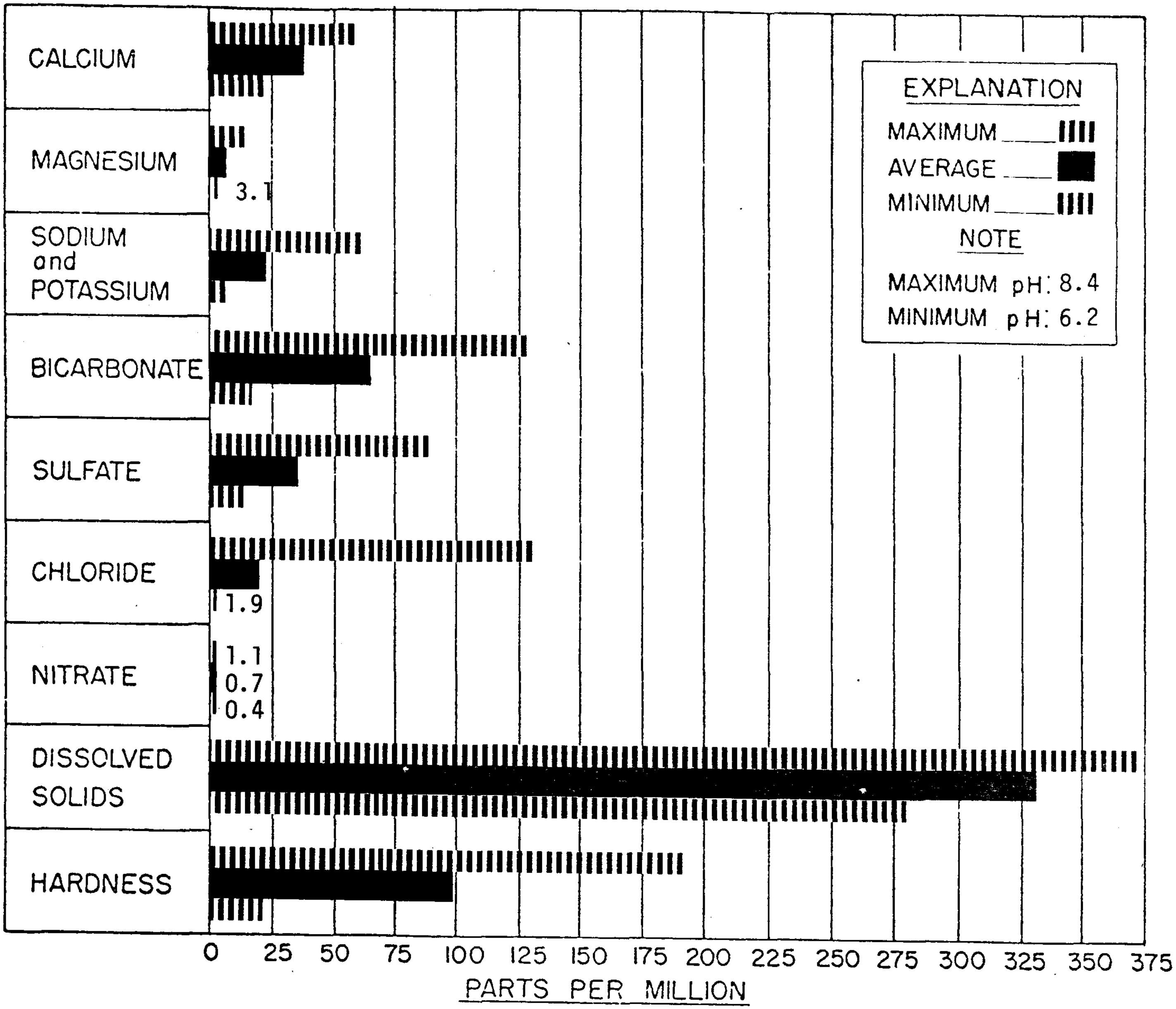
Red River at Pine Ridge
Period of Record 4-69 to 11-74

Figure H-3

Figure H-4

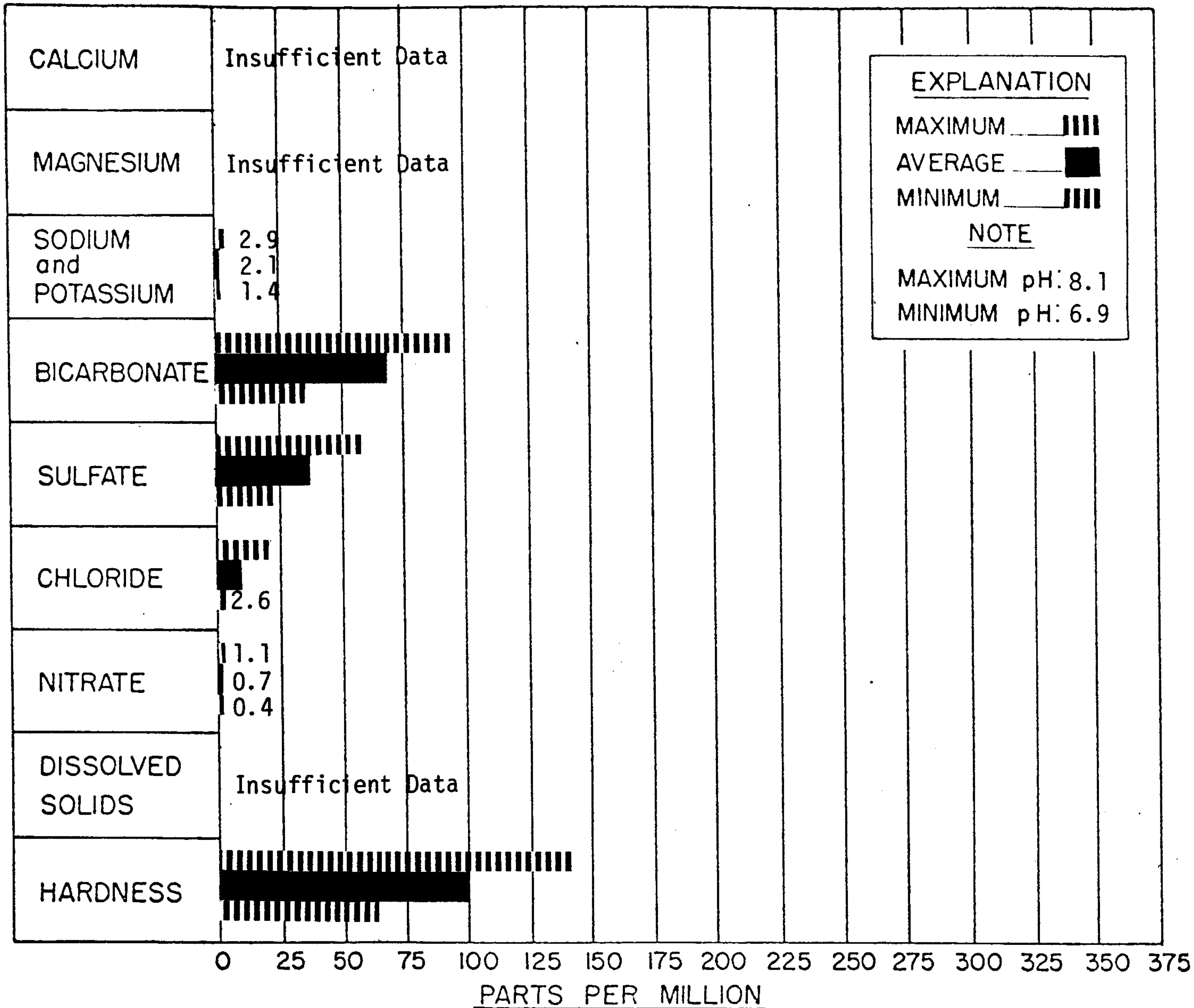


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,
Red River at Pine Ridge
Period of Record 1-73 to 11-74



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,
Kentucky River, Lock 4 at Frankfort
Period of Record 10-59 to 9-73

Figure H-5

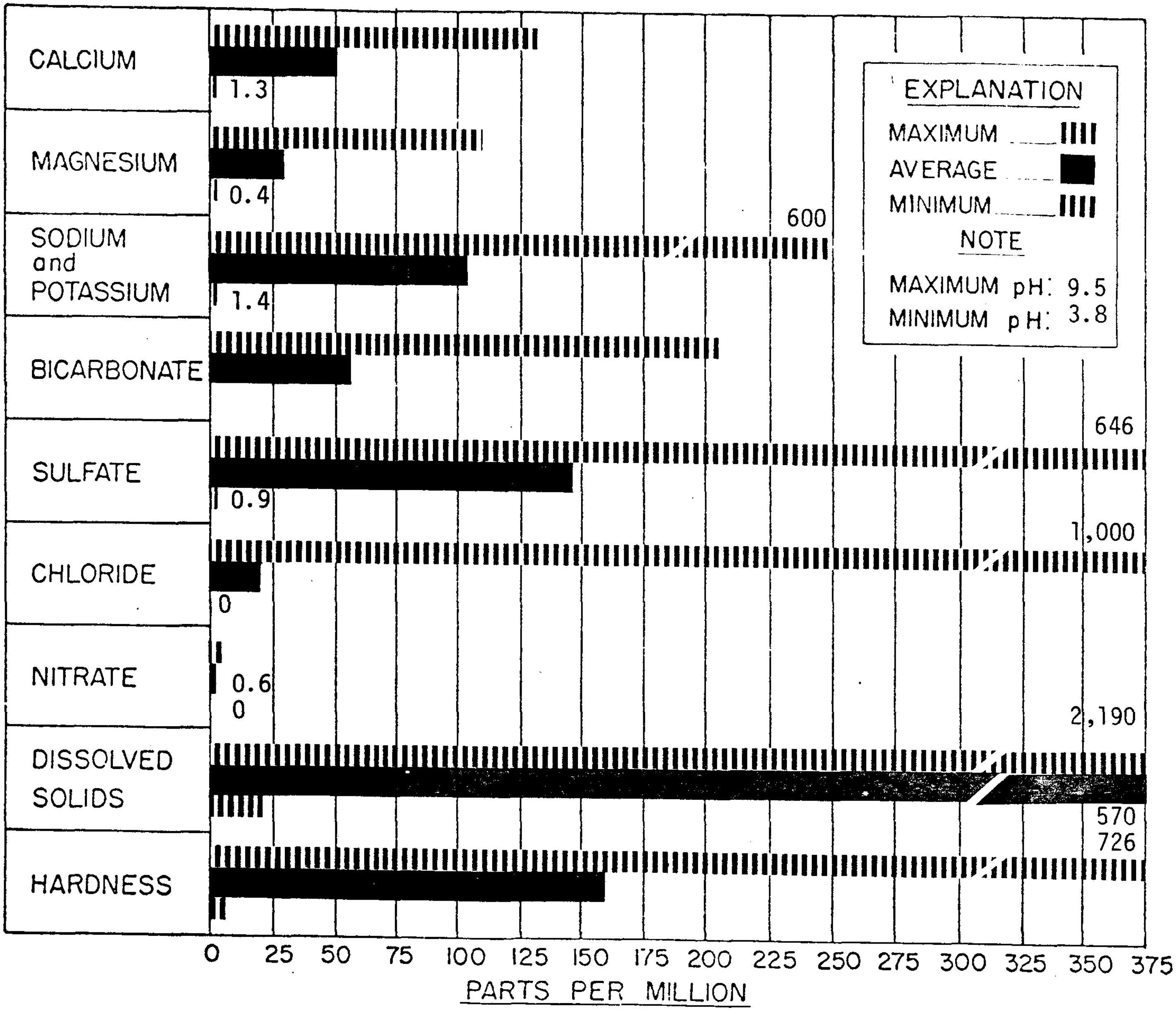


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Kentucky River, Lock 4 at Frankfort
Period of Record 1-73 to 11-74

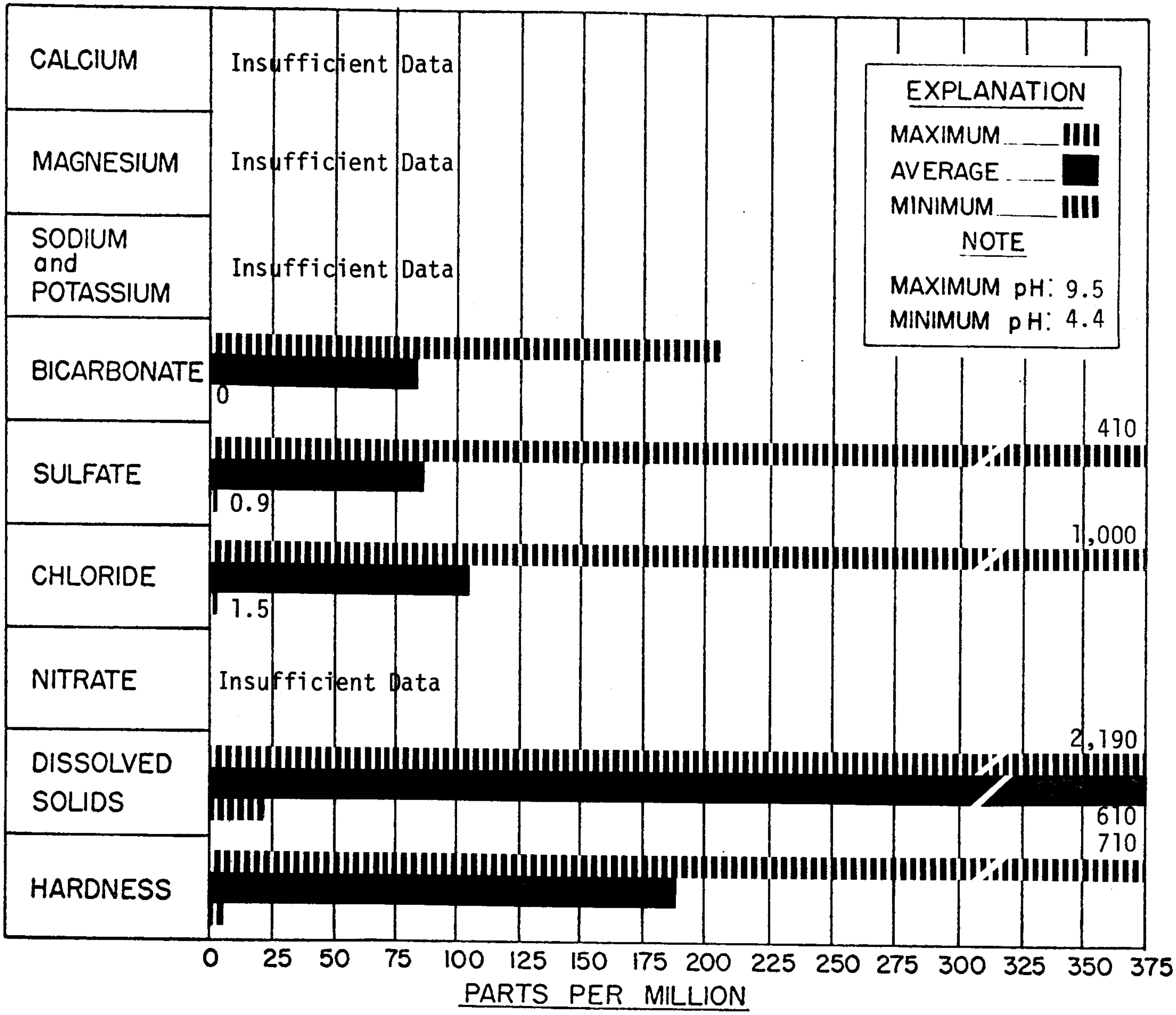
Figure H-6

Figure H-7



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

N. Fork Kentucky R. at Hazard
Period or Record 10-62 to 6-74



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

North Fork Ky. River at Hazard
Period of Record 1-73 to 6-74

Figure H-8

of less than 60 mg/l). The data studied indicates that the water in the Red River sub-basin is of the highest quality throughout the entire Kentucky River Basin.

The water quality of the main stem of the Kentucky River is demonstrated in Figures H-5 and H-6. This data was collected at Lock 4 near Frankfort and the river at this point is relatively insensitive due to its large drainage basin representation. This means that large influences are required to change the values measured in water quality. This data shows influences from upstream activities by an increase in dissolved solids and an increase in the hardness of the water. The hardness in the main stem is characterized as moderately hard (calcium bicarbonate hardness of 60 - 120 mg/l).

The North Fork of the Kentucky River at Hazard is just downstream of an intensive coal mining area and demonstrates the effects of such on water quality as can be seen in Figures H-7 and H-8. The North Fork is a relatively sensitive station showing a more rapid change in water quality. The water quality has been degraded by an increase in dissolved solids, hardness, sulfate, magnesium, calcium, sodium and potassium. The chloride levels are high as well as the sodium and potassium levels. This can be attributed to materials related to the coal mining industry. The acidity has increased as demonstrated by a decrease in pH. In general the water quality at this station is regarded as poor.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

The trace elements measured in the Kentucky River Basin were less than the Kentucky/FederalStandards for Drinking Water with the following exceptions. The station on the North Fork at Hazard yielded data that exceeded Kentucky/ Federal Water Quality Standards in the parameters of iron, manganese, and fluoride. These parameters can be directly or indirectly related to coal mining activities. A point of interest is that 128 million tons of coal were produced in Kentucky in 1973 and it is estimated that by 1985 this production level will reach 400 million tons in Kentucky or over three times that produced in 1973.

D. Waste Load Effects on Water Quality

Within the confines of this report, water quality is considered as affected when the dissolved oxygen concentration drops below 5 mg/l. Approximately 868 miles of stream length were studied under a model used to determine waste load allocations, developed in the Kentucky Continuing Planning Process for River Basin Management Planning. According to this data, approximately 150 miles of that stream length would have a dissolved oxygen concentration of less than 5 mg/l when the flow is equal to or less than the 10 year 7 day low flow. This is highly possible as the flow of many of the tributaries does drop to or below, the 10 year 7 day low flow. It is not predicted that the dissolved oxygen concentration in any segment of the main stem of the river will drop below 5 mg/l.

Of the 150 miles of stream length affected, approximately 124 miles or 83 per cent will be due to municipalities, and 26 miles due to other dischargers such as subdivisions, trailer parks, schools, etc. The waste loads causing this effect totaled approximate 32 million gallons per day (mgd) of discharges with 30 million of it contributed by municipalities and the remaining two million by other discharges.

E. Non-Point Source Effects

Non-point source effects can be summarized in the three categories of agriculture, mining and surface runoff. It is estimated that approximately 1,070 square miles of disturbed forest land, cropland, and field gullies and some 1,700 miles of streambank and roadbank erode excessively and contribute to sediment in the streams. It is further estimated that over 54 square miles of surface mined land is exposed and has an excessive erosion rate.

Surface runoff from urban areas is also a problem in cases where sizable cities are located on low flow streams. There are three such cases in the Kentucky River Basin at the cities of Lexington, Richmond and Danville. This type of source exerts a load on the receiving stream with respect to Biochemical Oxygen Demand (BOD) and suspended solids.

F. Water Uses

The most important use of water is for public water supply. Over 51 million gallons per day is withdrawn for use in this basin. Of this amount, approximately 24 million gallons per day or 48 per cent is used for public supply. The remaining 27 million gallons per day is used for industry. It should be noted that 27 percent, or fourteen million gallons per day, of the total withdrawal is withdrawn from groundwater.

Another major use of water in this basin is for recreational purposes. There are numerous boat docks, camp sites, beaches and other recreational facilities located in the Kentucky River Basin. Furthermore, according to the Kentucky Department of Fish and Wildlife, there are over 2,000 miles of stream in this basin capable of providing a sport fishery with a grand total of 99 species of fishes representing 18 families.

Generally, water in the basin is widely used in the agricultural industry primarily for livestock watering with a small amount used for irrigation. The water in the basin is of sufficient quality for this use except in areas of extensive coal mining, i.e., in the headwaters.

G. Water Quality Changes

In general, the quality of the water in the Kentucky River Basin is not changing according to the data studied. However, the data taken at the station on the North Fork of the Kentucky River at Hazard reveals that the quality of the water is deteriorating. The concentrations of no less than nine of the parameters studied have increased by considerable amounts. With the energy crisis demanding greater and greater amounts of coal, there is the potential for these problems to increase even more. Much care must be taken in this area to prevent the quality of the water from deteriorating as coal production increases and an effort must be made to upgrade the existing quality of the water.

III. Summary

As stated earlier in this report, the quality of the water in the Kentucky River Basin is good at the station on the main stem of the river at Lock 4 near Frankfort, on the Red River at Pine Ridge and on Eagle Creek at Glencoe. However, the station on the North Fork of the Kentucky River at Hazard reflects the effects of coal mining on water quality.

The two main problems in the basin with regards to water quality are siltation and municipal organic wasteloads.

The problem of municipal organic wasteloads is twofold: Inadequate treatment facilities and improper operation of some existing treatment facilities. More emphasis should be placed on the training of wastewater treatment plant operators and recruiting of better qualified personnel to insure proper operation and maintenance of treatment facilities. According to the data, 38 per cent of the existing treatment facilities in this basin need improvements as they are affecting the quality of the water. It should also be noted that 19 per cent of the incorporated cities in the basin presently have no sewers.

The siltation and organic load problems related to urban runoff from sizable cities located on low-flow streams can be improved by the installation or upgrading of storm sewer systems.

The siltation problem related to coal production is localized in the headwaters. The coal producing counties that contribute to this basin are Bell, Clay, Estill, Harlan, Knott, Knox, Leslie, Letcher and Perry. The logging of forest land in preparation for strip mining can result in high runoff rates and serious erosion while the actual strip mining leads to sedimentation from upheaval of surface soil. With today's emphasis on increased coal production, this problem will have to be controlled to prevent further degradation of the water quality. As shown earlier in this report, the quality of the water is already below acceptable standards in this area and measures for improvement need to be emphasized and implemented.

The water quality problems related to coal production cannot be over emphasized. The State of Kentucky is the largest coal producing state in the nation and its production level is predicted to triple within the next few years. This amount of coal mining activity could have a disasterous, practically irreversible effect on the quality of the waters of Kentucky.

TABLE H-1

SUB-BASINS OF 200 SQUARE MILES OR GREATER IN

THE KENTUCKY RIVER BASIN

Sub-basins	Square Miles
North Fork of Kentucky	1,883.0
South Fork of Kentucky	748.0
Middle Fork of Kentucky	559.0
Red River	487.00
Dix River	442.0
Elkhorn Creek (at lower Dam Site) Mile 2.5	492.0
Eagle Creek	519.0
Station Cam Creek	217.0

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE H-2

COUNTY AREA IN THE KENTUCKY RIVER BASIN

County	Total Area (sq. miles)	Area in Basin (sq. miles)	County	Total Area (sq. miles)	Area in Basin (sq. miles)
Anderson	206	70	Lee	210	210
Bell	370	15	Leslie	409	409
Boyle	183	80	Letcher	339	290
Breathitt	494	494	Lincoln	340	187
Carroll	130	86	Madison	446	446
Clark	259	130	Menifee	210	65
Clay	474	430	Mercer	256	102
Estill	260	260	Montgomery	204	35
Fayette	280	280	Owen	351	351
Franklin	211	211	Owsley	197	197
Garrard	236	236	Perry	341	341
Grant	249	249	Powell	173	173
Harlan	469	70	Rockcastle	311	60
Henry	289	260	Scott	284	284
Jackson	337	135	Shelby	383	70
Jessamine	177	177	Trimble	146	60
Knott	356	255	Wolfe	227	227
Knox	373	38	Woodford	193	193
			Total		7,033

SOURCE: Rand McNally Standard Reference Map and Guide of Kentucky, 1972.

TABLE H-3

SLOPES AND ELEVATIONS OF PRINCIPAL TRIBUTARIES

IN THE KENTUCKY RIVER BASIN

STREAM	LENGTH (Miles)	Max. El. (m.s.l.)	Min. El. (m.s.l.)	AVERAGE SLOPE (ft./miles)
N. Fork of Kentucky River	148.1	1,109	634	3.21
M. Fork of Kentucky River	43.3	757	627	3.00
S. Fork of Kentucky River	85.0	1,250	634	7.25
Goose Creek	21.8	830	754	3.49
Troublesome Creek	42.4	1,004	720	6.69
Red River	59.5	713	566	2.47
Otter Creek	13.1	880	566	23.97
Boone Creek	7.2	780	549	32.08
Silver Creek	39.2	936	531	10.33
Paint Lick Creek	32.0	920	531	12.16
Hickman Creek	31.5	910	514	12.57
Jessamine Creek	13.1	860	519	26.03
Clarks Run Creek	10.4	920	750	16.35
Dix River H.W. to mp 34.6	23.2	822	750	3.27
	0.0 slope from mp 34.60 to mouth including reservoir			
Glenns Creek	12.5	830	469	28.88
Elkhorn Creek	90.6	950	454	5.48
Drennon Creek	16.6	800	428	22.41
Stephens Creek	20.9	920	598	15.41
Clarks Creek	15.4	791	586	13.31
Eagle Creek	81.4	737	428	3.80
Little Eagle Creek	12.6	914	737	14.05

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE H-5

LAKES IN THE KENTUCKY RIVER BASIN

Location	County	Surface Area (Acres)	Capacity Acre-Feet
Fishpond Lake	Letcher County	31	1,037
Taylor Fork Lake	Madison County	169	3,572
Corinth Lake	Grant County	96	1,612
Bullock Pen	Grant County	134	2,464
Elmer Davis Lake	Owen County	149	3,151
Pan Bowl Lake	Jackson County	98	1,298
Lexington Reservoirs	Fayette County	408	3,850
Mill Creek Lake	Wolfe County	41	1,049
Elk Lake	Owen County	207	2,654
Herrington Lake	Mercer County	2,940	230,500
Kentucky Utility Fly Ash Disposal	Carroll County	89	2,491
Lake Vega	Madison County	132	1,557
Boltz Lake	Grant County	92	2,168
Total	--------------------	4,586	257,403
Federal			
Buckhorn Lake	Leslie & Perry County	1,230	21,800
Carr Fork Lake	Knott County	710	6,480
Total	--------------------	1,940	28,280
Grand Total	--------------------	6,526	285,683

SOURCE: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table H-6

POPULATION AND FACILITY GRANT STATUS IN THE KENTUCKY RIVER BASIN

County - Cities	Total Population	Population in Basin	Project Type	Comments
Anderson	9,358	2,000		
Bell	31,087	700		
Boyle	21,090	16,800		
Danville		12,400	Step 1	Pending
Junction City		1,046	Step 1	Pending
Breathitt	14,221	14,221		
Jackson		1,887	Step 1	Pending
Carroll	8,523	7,000		
Carrollton		3,884	Step 1	Pending
Clark	24,090	5,300		
Clay	18,481	16,800		
Manchester		1,664	Step 1	Pending
Estill	12,752	12,752		
Irvine-Ravenna		3,702	Step 1	Pending
Fayette	174,323	174,323		
Lexington-Main		73,500	Step 1	
Lexington-West Hickman		43,500	Step 1	
Franklin	34,481	34,481		
Frankfort		22,700		
Garrard	9,457	9,457		
Lancaster		3,230	Step 1	
Grant	9,999	7,700		
Williamstown		2.063	Step 1	
Dry Ridge		1,100	Step 11	No Sewers
Harlan	37,370	3,800		
Henry	10,910	7,200		
New Castle		755	Step 1	
Pleasureville		747	Step 1	Pending, No Sewers
Jackson	10,005	3,900		
Jessamine	17,430	17,430		
Nicholasville		5,829	Step 1	Pending
Wilmore		3,466		No Planning

TABLE H-6 (continued)

County - Cities	Total Population	Population in Basin	Project Type	Comments
Knott	14,698	10,800		
Hindman		808	Step 1	Pending
Knox	23,689	1,800		
Lee	6,587	6,587		
Beattyville		923	Step 1	Pending
Leslie	11,623	11,623		
Hyden		482		No Planning
Letcher	23,165	17,900		
Whitesburg		1,137	Step 1	Pending
Neon-Fleming		1,178	Step 1	No Sewers
Lincoln	16,633	10,900		
Stanford		2,474	Step 1	
Crab Orchard		861	Step 1	No Sewers
Hustonville		413	Step 1	No Sewers
Madison	42,730	42,730		
Berea #1		4,600	Step 1	Pending
Berea #2		2,300	Step 1	Pending
Richmond #1		10,100	Step 1	Pending
Richmond #2		7,700	Step 1	Pending
Menifee	1,100			
Mercer	15,960	3,700		
Burgin		1,002	Step 1	Pending-No Sewers
Montgomery	15,364	1,700		
Owen	7,470	7,470		
Owenton		1,280		No Planning
Owsley	5,023	5,023		
Booneville		126		No Planning
Perry	26,259	26,259		
Hazard		5,459		No Planning
Vicco		377	Step 1	Pending
Powell	7,704	7,704		
Stanton		2,037	Step 1	Pending
Clay City		938	Step 1	Pending
Rockcastle	12,305	2,700		
Brodhead		769		No Planning

TABLE H-6 (continued

County - Cities	Total Population	Population in Basin	Project Type	Comments
Scott	17,948	17,948		
Georgetown		8,629	Step 1	Pending
Stamping Ground		411	Step III	No Sewers
Sadieville		272		No Planning-No Sewers
Shelby	18,999	2,600		
Trimble	5,349	1,900		
Wolfe	5,669	5,669		
Campton		419	Step 1	Pending
Woodford	14,434	14,434		
Versailles		5,679	Step III	Step 1 Pending
Midway		1,278	Step 1	Pending

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality.

TABLE H-7

Organic Loads Affecting Streams in the Kentucky River Basin

Length of streams to which treated organic loads are discharged		868
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		150
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	124
	Industrial Discharges	---
	Other Discharges	26

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg.l when the stream flow is less than the once in ten year, seven day, low flow.

Table H-8

LOCKS AND DAMS ON THE KENTUCKY RIVER

Lock No.	Miles Above Mouth	Length of Pool Above Dam (miles)
1	4.0	27.0
2	31.0	11.0
3	42.0	23.0
4	65.0	17.2
5	82.2	14.0
6	96.2	20.8
7	117.0	22.9
8	139.9	17.6
9	157.5	18.9
10	176.4	24.6
11	201.0	19.9
12	220.9	19.0
13	239.9	9.1
14	249.0	-

Navigation Charts
U. S. Army Corps of Engineers
Louisville District

Table H-9

Water Quality Data for Kentucky River Basin

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	pH Specific Units, Kentucky (Ky. Std.) 6 to 9						
N. Fk. Kentucky R. at	276	7.2	0.7	9.5	3.8	10-62	6-74
Hazard	32	7.4	1.0	9.5	4.4	1-73	6-74
Red R. at Pine Ridge	49	7.2	0.3	7.9	6.7	4-69	7-74
	17	7.4	0.4	7.9	6.7	1-73	7-74
Ky. River, Lock 4 at	285	7.5	0.4	8.4	6.2	10-59	9-73
Frankfort	14	7.6	0.4	8.1	6.9	1-73	9-73
Eagle Creek at Glencoe	42	7.5	0.4	8.2	5.2	1-62	7-74
	16	7.5	0.7	8.2	5.2	2-73	7-74
	Conductivity Micromhos, Ky. Std. 800 micro mhos						
N. Fk. Kentucky R. at	310	460	360	3,860	21.4	10-62	6-74
Hazard	34	620	880	3,860	21.4	1-73	6-74
Red R. at Pine Ridge	54	110	60	390	58	4-69	11-74
	22	120	90	390	58	1-73	11-74
Ky. River, Lock 4 at	376	250	100	675	76	10-59	6-74
Frankfort	17	230	50	320	145	1-73	6-74
Eagle Creek at Glencoe	49	350	120	617	17	1-62	11-74
	23	350	150	617	17	2-73	11-74
	Dissolved Solids - Milligrams per liter (mg/1) Ky. Std. 500 micro mhos						
N. Fk. Kentucky R. at	15	570	630	2,190	21	10-68	4-74
Hazard	10	610	780	2,190	21	3-74	4-74
Red River at Pine Ridge	50	68	34	211	38	4-69	11-74
	18	78	53	211	38	1-73	11-74
Ky. River, Lock 4 at Frankfort	5	330	37	372	279	12-68	10-72
Eagle Creek at Glencoe	46	210	70	364	27	8-70	11-74
	23	210	90	364	27	2-73	11-74
	Alkalinity mg/1, No Standard						
N. Fk. Kentucky R. at	177	55	42	205	0	11-64	6-74
Hazard	32	82	71	205	0	1-73	6-74
Red R. at Pine Ridge	53	32	31	193	9	4-69	11-74
	21	40	46	193	9	1-73	11-74
Ky. River, Lock 4 at	218	65	19	128	16	10-59	9-73
Frankfort	14	67	19	92	34	1-73	9-73
Eagle Creek at Glencoe	47	140	44	217	7	8-70	11-74
	23	140	56	217	7	2-73	11-74

Table H-9

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	Hardness mg/l, 0-60 soft, 61-120 moderately hard, 121-180 hard, over 180 very hard						
N. Fk. Kentucky R. at	267	160	110	726	5	10-62	4-74
Hazard	30	190	180	710	5	1-73	4-74
Red River at Pine Ridge	50	47	34	180	18	4-69	11-74
	18	59	54	180	18	1-73	11-74
Ky. River, Lock 4 at	370	99	29	192	21	10-59	9-73
Frankfort	14	100	23	140	63	1-73	9-73
Eagle Creek at Glencoe	49	180	63	300	8	1-62	11-74
	23	180	80	300	8	2-73	11-74
	Color - Platinum Cobalt Color Units, Porp. E.P.A. Std. 75 Units						
N. Fk. Kentucky River at	131	8	8.4	50	0	10-62	4-74
Hazard	10	9	11	40	3	3-74	4-74
Red River at Pine Ridge	46	15	14	70	0	4-69	11-74
	13	11	7.5	30	0	1-73	11-74
Ky. River, Lock 4 at Frankfort	138	9	7.8	50	0	10-59	10-72
Eagle Creek at Glencoe	45	51	65	300	0	1-62	11-74
	20	61	88	300	0	2-73	11-74
	Sodium mg/l, No Standard						
N. Fk. Kentucky R. at Hazard	19	95	160	570	0.5	7-65	4-74
Red River at Pine Ridge	50	3	2	14	1.4	4-69	11-74
	18	4	3	14	1.4	1-73	11-74
Ky. River, Lock 4 at Frankfort	17	20	18	56	4.1	10-59	10-72
Eagle Creek at Glencoe	48	5	2	9.1	0.8	1-62	11-74
	23	5	2.2	9.1	0.8	2-73	11-74
	Potassium mg/l, No Standard						
N. Fk. Kentucky River at Hazard	16	7.5	7.7	29	0.9	7-65	4-74
Red River at Pine Ridge	50	1.9	0.7	3.8	0.8	4-69	11-74
	18	1.9	0.8	3.6	0.8	1-73	11-74
Ky. River, Lock 4 at	17	2.6	0.8	4.6	1.6	10-59	10-72
Frankfort	4	2.1	0.7	2.9	1.4	4-73	10-74
Eagle Creek at Glencoe	48	3.2	1.2	5.8	1.1	1-62	11-74
	23	3.2	1.4	5.8	1.1	2-73	11-74
	Chloride mg/l, Prop. E.P.A. Std. 250 mg/l						
N. Fk. Kentucky River at	267	19	91	1,000	0	10-62	4-74
Hazard	30	104	260	1,000	1.5	1-73	4-74
Red River at Pine Ridge	50	4	1.9	8	1.1	4-69	11-74
	18	4	1.9	7.6	1.1	1-73	11-74
Ky. River, Lock 4 at	272	20	23	130	1.9	10-59	9-73
Frankfort	14	9	5.4	20	2.6	1-73	9-73

Table H-9

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
Eagle Creek at Glencoe	49	8	11	80	1	1-62	11-74
	23	6	2.8	10	1.9	2-73	11-74
	Sulfate mg/l, Prop. E.P.A. Std. 250 mg/l						
N. Fk. Kentucky River at	268	146	99	646	0.9	10-62	6-74
Hazard	32	87	84	410	0.9	1-73	6-74
Red River at Pine Ridge	55	16	5.6	43	7.9	4-69	11-74
	21	17	8.2	43	7.9	1-73	11-74
Ky. River, Lock 4 at	272	34	13	89	13	10-59	9-73
Frankfort	14	36	10	57	22	1-73	9-73
Eagle Creek at Glencoe	49	43	20	100	0.3	1-62	11-74
	23	46	25	100	0.3	2-73	11-74
	Nitrate - N mg/l, Prop. E.P.A. Std. 10 mg/l						
N. Fk. Kentucky River at Hazard	43	0.6	0.7	4	0	4-72	4-74
Red River at Pine Ridge	15	0.2	0.1	0.5	0.02	6-72	8-74
Ky. River, Lock 4 at Frank-	34	0.7	0.2	1.1	0.4	4-72	9-73
fort	14	0.7	0.2	1.1	0.4	1-73	9-73
Eagle Creek at Glencoe	18	0.4	0.3	0.8	0	10-72	7-74
	Fluoride mg/l, Prop. E.P.A. Std. 10 mg/l						
N. Fk. Kentucky River at Hazard	28	0.6	0.8	3.7	0.1	10-68	4-74
Red River at Pine Ridge	50	0.2	0.3	2	0	4-69	11-74
	18	0.2	0.5	2	0	1-73	11-74
Ky. River, Lock 4 at	18	0.2	0.1	0.4	0.1	10-59	10-72
Frankfort	54	0.6	1.3	0.9	0.1	1-70	11-74
Eagle Creek at Glencoe	49	0.3	0.2	1.1	0.1	1-62	11-74
	23	0.2	0.1	0.5	0.1	2-73	11-74
Kentucky R. at Lexington	53	0.4	0.3	0.9	0	3-69	11-74
	Calcium - Micrograms per liter (ug/l) No Std.						
N. Fk. Kentucky River at Hazard	15	50	37	131	1.3	10-68	4-74
Red River at Pine Ridge	50	12	10	57	3.5	4-69	11-74
	18	16	16	57	3.5	1-73	11-74
Kentucky River, Lock 4 at Frankfort	19	37	11	57	21	10-59	10-72
Eagle Creek at Glencoe	48	58	20	88	2.7	1-62	11-74
	23	58	25	88	2.7	2-73	11-74

Table H-9

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	Magnesium mg/l , No Standard						
N. Fk. Ky. River at Hazard	15	28	31.3	110	0.4	10-68	4-74
Red River at Pine Ridge	50	4	3.0	23	2.0	4-69	11-74
	18	4.8	4.9	23	2.0	1-73	11-74
Ky. River, Lock 4 at Frankfort	19	7.5	3.4	14	3.1	10-59	10-72
Eagle Creek at Glencoe	48	8.4	4.0	20	0.4	1-62	11-74
	23	9.1	5.0	20	0.4	2-73	11-74
	Cadmium ug/l, micrograms per liter, Ky Std. 100 ug/l						
N. Fk. Kentucky River at	12	0.3	1.2	4	0	10-63	6-74
Hazard	6	0.7	1.6	4	0	4-74	6-74
Ky. River, Lock 4 at	13	0	0	0	0	11-62	6-74
Glencoe	54	1	0.9	5	0	1-70	11-74
Eagle Creek at Glencoe	4	1.8	2.1	4	0	3-74	6-74
Ky. River at Lexington	53	0.6	0.5	1	0	3-69	11-74
	Manganese ug/l, micrograms per liter, Prop. Std. 50 ug/l						
N. Fk. Kentucky River at Hazard	5	32	31	83	0	4-74	4-74
Red River at Pine Ridge	26	26	21	67	0	10-71	11-74
Eagle Creek at Glencoe	29	29	36	180	0	10-71	11-74
	Iron ug/l, micrograms per liter, E.P.A. Std. 300 ug/l						
N. Fk. Kentucky River at	32	199	426	1,800	0	12-64	4-74
Hazard	11	434	666	1,800	10	3-74	4-74
Red River at Pine Ridge	27	154	118	480	0	10-71	11-74
Ky. River, Lock 4 at Frankfort	71	45	62	320	0	10-60	9-65
Eagle Creek at Glencoe	31	96	75	280	0	10-71	11-74
	Chromium ug/l, micrograms per liter, Ky. Std. 50 ug/l						
N. Fk. Ky. River at Hazard	6	1.7	4.1	10	0	4-74	6-74
Ky. River, Lock 4 at Frankfort	52	1.5	1.6	7	0	1-70	11-74
Eagle Creek at Glencoe	4	0.3	0.5	1	0	3-74	6-74
Ky. River at Lexington	53	1.5	1.5	6	0	3-69	11-74
	Lead ug/l, micrograms per liter, Ky. Std. 50 ug/l						
N. Fk. Ky. R. at Hazard	11	1.6	4.2	14	0	10-63	4-74
Ky. R., Lock 4 at Frankfort	13	1.4	3.2	9	0	11-62	6-74
	50	8.4	5.5	34	1	1-70	11-74
Eagle Creek at Glencoe	4	8	16	32	0	3-74	6-74
Ky. River at Lexington	48	8.3	5	29	1	3-69	11-74

Table H-9

Station	#Obs.	Mean	S	Max.	Min.	Beg. Date	End Date
	Silver	ug/l, micrograms per liter, Ky. Std. 50 ug/l					
Ky. River, Lock 4 at Frankfort	54	0.6	0.6	3	0	1-70	11-74
Kentucky River at Lexington	53	0.5	0.6	2	0	3-69	11-74
	Arsenic	ug/l, micrograms per liter, Ky. Std. 50 ug/l					
N. Fk. Kentucky River at	12	0.3	0.8	2	0	10-63	6-74
Hazard	6	0.7	1	2	0	4-74	6-74
Ky. River, Lock 4 at	14	1.1	3.3	12	0	11-62	6-74
Frankfort	14	0.5	0.5	1	0	1-71	4-74
Eagle Creek at Glencoe	4	1	1.2	2	0	3-74	6-74
Kentucky River at Lexington	13	0.7	1.1	1	0	7-71	4-74

#Obs: Total number of observations in period shown.

S: Standard Deviation

THE LICKING RIVER BASIN

This report is in three parts. The first is a general basin description, the second describes the water quality, and the third part summarizes the problems and offers some general solutions.

I. A Description of the Licking River Basin

A. Geography

The Licking River Basin is located entirely within the eastern portion of the Commonwealth of Kentucky. The Licking River rises in southeastern Kentucky and flows northwesterly to its confluance with the Ohio River, opposite Cincinnati, Ohio. The total drainage area of the basin is 3,700 sq. mi. which is approximately 9 per cent of the land area of the state and includes all or portions of 21 counties. The basin is shaped much like an elongated diamond with an axis of about 130 miles and a minor axis of about 60 miles. The main stem is approximately 320 miles long.

The basin extends from Covington and Newport, Kentucky in the north, to below Salyersville in the south and from beyond Flemingsburg and Morehead in the east to Winchester in the west.

B. Topography

The Licking River drainage area is entirely south of the glaciated portion of the Ohio River Basin and physical features of the basin are generally the result of geological strata exposed by differential erosion following the broad uplift of the Paleozoic Era known as the Cincinnati Arch. The Licking River Basin exhibits four distinct physiographic types. The river rises in the Eastern Coal Fields of the Kanawha section of the (1) Appalachian Plateau, which has narrow ridges and crooked steep sided valleys. It flows through the (2) Knobs and the (3) Outer Blue Grass Regions. The South Fork drains a portion of the (4) Inner Blue Grass region of the Interior Low Plateau. The Knobs is an area of conical hills with rather broad valleys. The Outer Blue Grass is rather gently rolling except where the streams have entrenched themselves into deep valleys. The Inner Blue Grass region is gently rolling upland. There are no natural lakes in the basin. The generally flat topography of the Licking River Basin allows little reaeration due to the slope of the streams. Reaeration is the replacement of dissolved oxygen from the atmosphere which was used to stabilize organic matter. The river courses from an elevation of 998 ft. mean sea level (m.s.l.) at its headwaters to an elevation of 420 ft. m.s.l. at the confluence with the Ohio River for some 320 miles. The main stem has an average slope of approximately 1.9 ft./mi. Over the low half of the river the average slope is 1.3 ft./mi. The slopes of the tributaries average between 1 to 2 ft./mi. for the North and South Forks and into the hundreds of feet per mile in some of the smaller tributaries. A slope in the range of 0 to 2 ft./mi. is considered low, 2 to 6 ft./mi. is moderate and 6 to 10 ft./ mi. is high as it relates to the effect of reaeration.

C. Geology

The major geologic influence on the quality of the water in the Licking River Basin is the occurance of limestone throughout the basin. Limestone contributes calcium and magnesium through solution from the soil and rocks which imparts hardness to the water. The coal field does not appear to be having a significant effect on water quality at this time.

The groundwater resources are limited by the low yield of the aquifers in the basin, thus restricting the use of groundwater as a major source of water supply.

D. Hydrology

During the late summer and early autumn portions of the Licking River have flows of less than 5 cubic feet per second (Table I-2). Such low flows severly limit the capacity of a stream to maintain the standard of 5 mg/l of dissolved oxygen. Cave Run Reservoir near Farmers, Kentucky, 174 miles from the mouth, was built to store 47,000 acre feet of water for hood control, water supply recreation and low flow augmentation. Cave Run Reservoir is designed to augment the low flow in the Licking River by 50 cubic feet per second (c.f.s.).

Table I-2

Surface Flow in the Licking River Basin

Station	Period of Record	Drainage Area	Average Flow	Maximum Flow	Minimum Flow	7 Day 10 Yr. Low Flow
Licking River at Farmers, Kentucky	36 yr.	827 sq. mi.	1,060 cfs, 1.3 cfs/sq. mi.	24,000 cfs, 29 cfs/sq. mi.	0.7 cfs, 0.0 cfs/sq. mi.	54.4 cfs
South Fork Licking River at Cynthiana, Kentucky	36 yr.	621 sq. mi.	754 cfs, 1.2 cfs/sq. mi.	35,300 cfs, 56.8 cfs/sq. mi.	0.3 cfs, 0.0 cfs/sq. mi.	.9 cfs
Licking River at Catawba, Kentucky	48 yr.	3,300 sq. mi.	4,119 cfs, 1.2 cfs/sq. mi.	95,000 cfs, 28.8 cfs/sq. mi.	2.5 cfs, 0.0 cfs/sq. mi.	62 cfs

Information is from the "Surface Water Records" published by the United States Geological Survey. The 7-day - 10-year low flow information was taken from the Waste Load Allocation, a part of the Kentucky 303e River Basin Continuing Planning Process.

E. Population

The population of the Licking River Basin was 211,000 in 1970. The distribution throughout the basin is fairly uniform except for a major population center in Campbell and Kenton Counties, composing a part of the SMSA of Cincinnati, Ohio. Although Campbell and Kenton Counties don't discharge treated sewage into the Licking River, combined sewer overflow and street run-off do affect water quality in the lower Licking River. The total urban population of the basin is 106,000 or 50 per cent of the whole basin. The other 50 per cent is in rural areas.

II. Basin Water Quality

The water quality of the Licking River Basin has been determined by using both a computer model and data collected at three monitoring stations. These sources give an overall picture of the basin which shows problems caused by sewage treatment plant effluent and erosion.

A. Description of Sampling Stations

The Salyersville monitoring station, the farthest upstream of the three stations, is on the Licking River 1.2 miles west of Salyersville and 266 miles from the mouth. The drainage area at this point is 140 sq. mi.

The second station, at McKinneysburg, on the Licking River is 64 miles from the mouth and has a drainage area of 2,300 sq. mi.

The last station is at the Kenton County water intake on the Licking River approximately 2 miles from the mouth at the Ohio River. The drainage area at this station is approximately 3,700 sq. mi.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

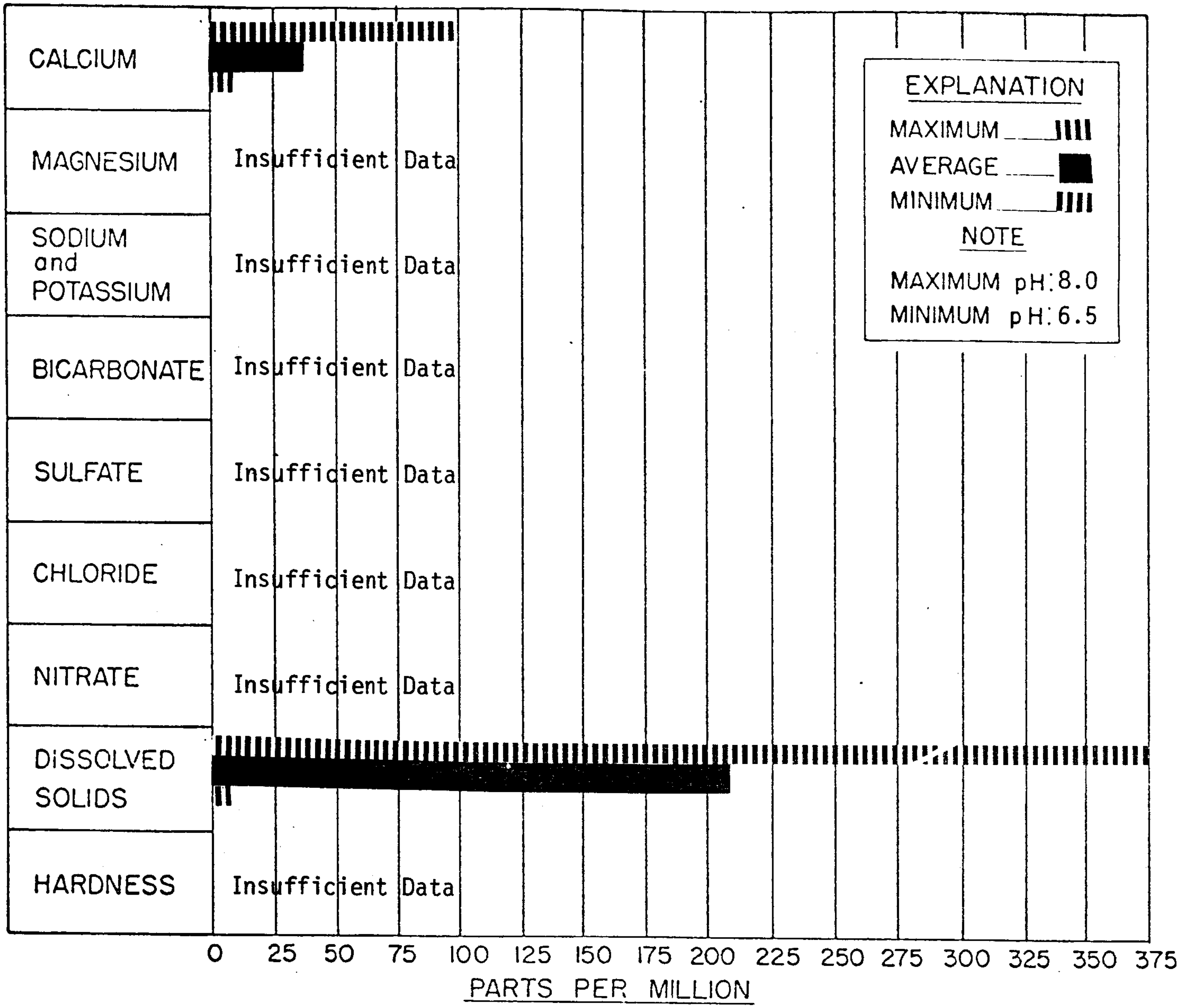
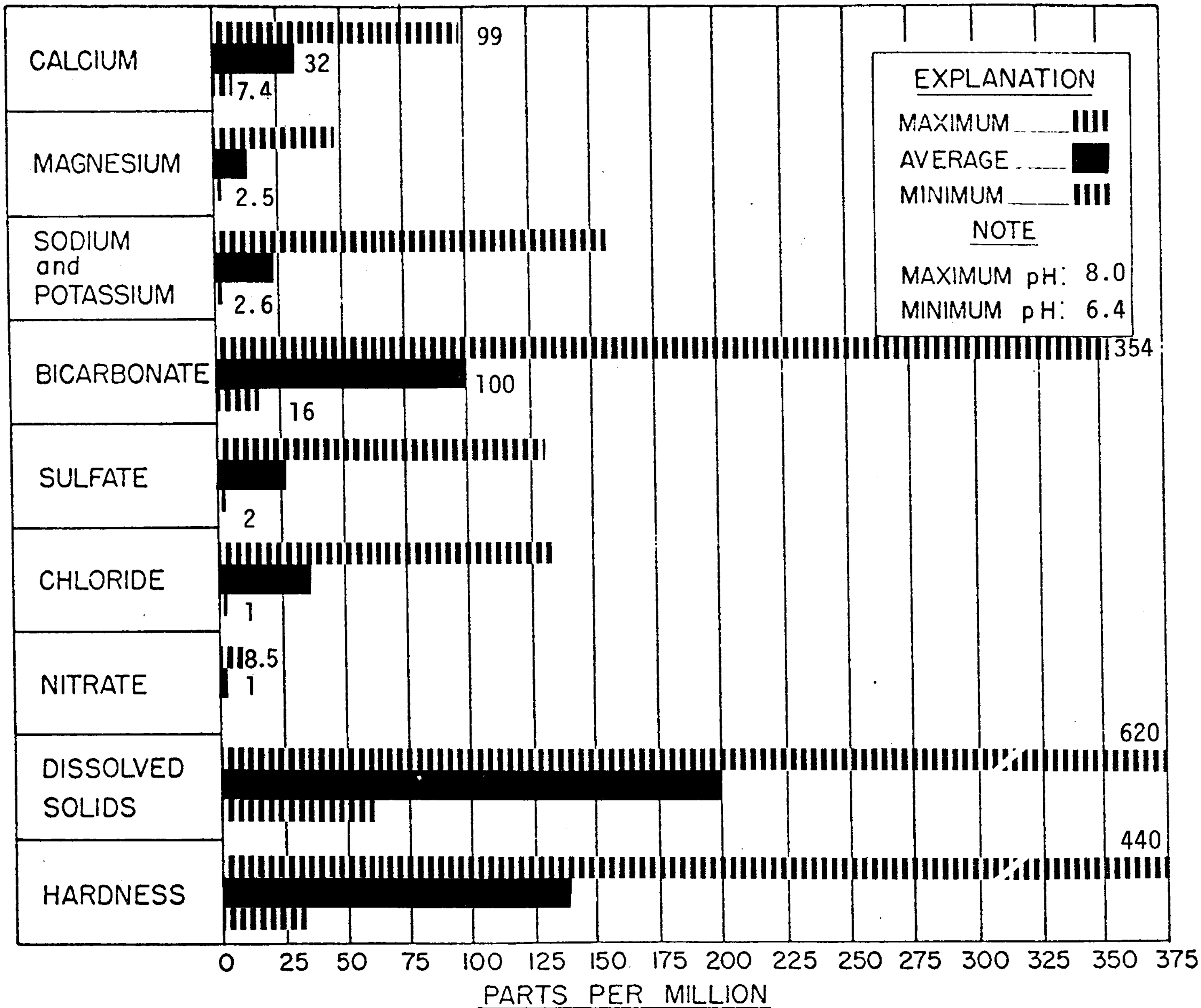


Figure I-1

MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Licking River at Salyersville

Period of Record: 1-73 to 11-74

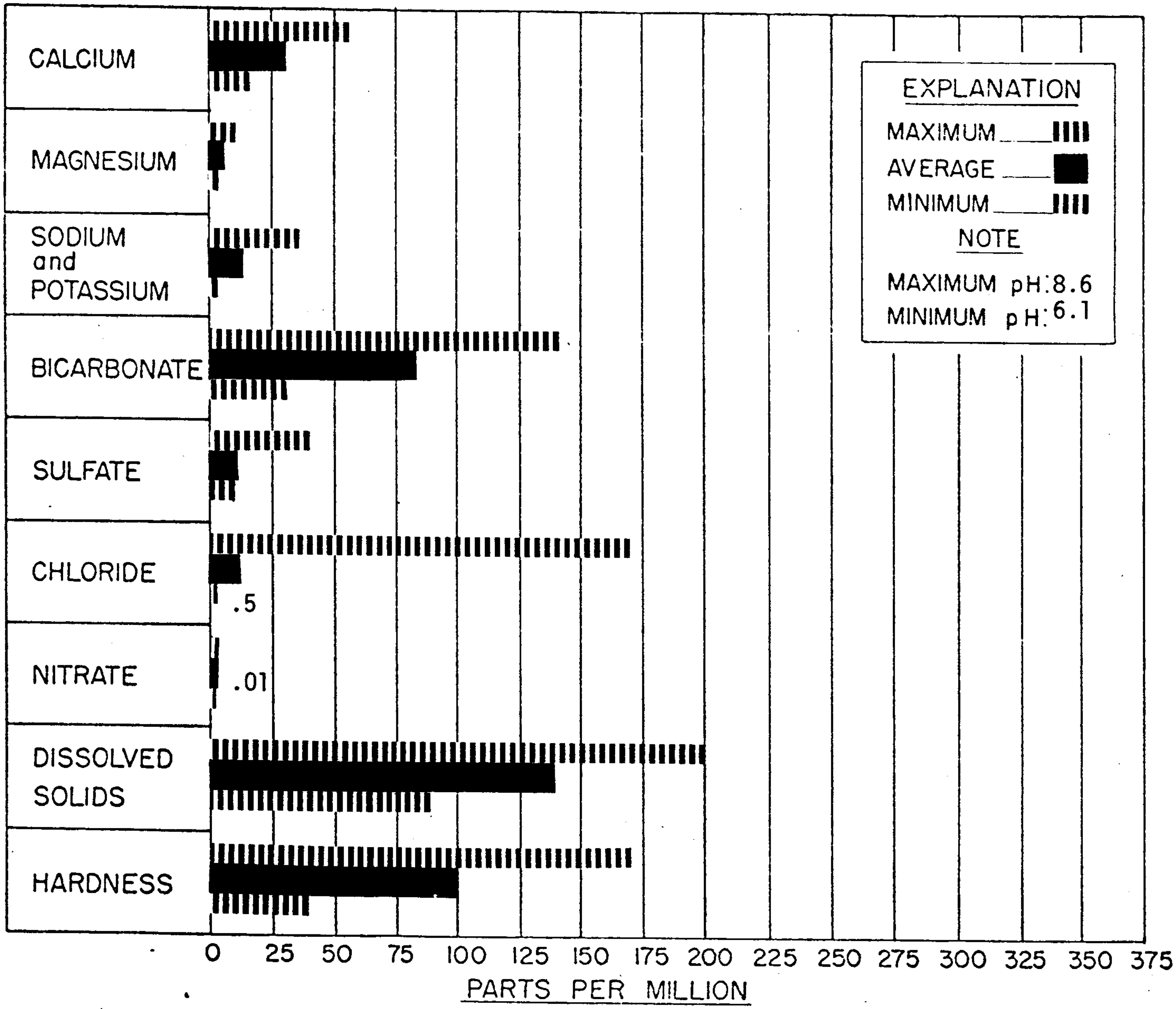


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Licking River at Salyersville

Period of Record 5-65 to 11-74

Figure I-2

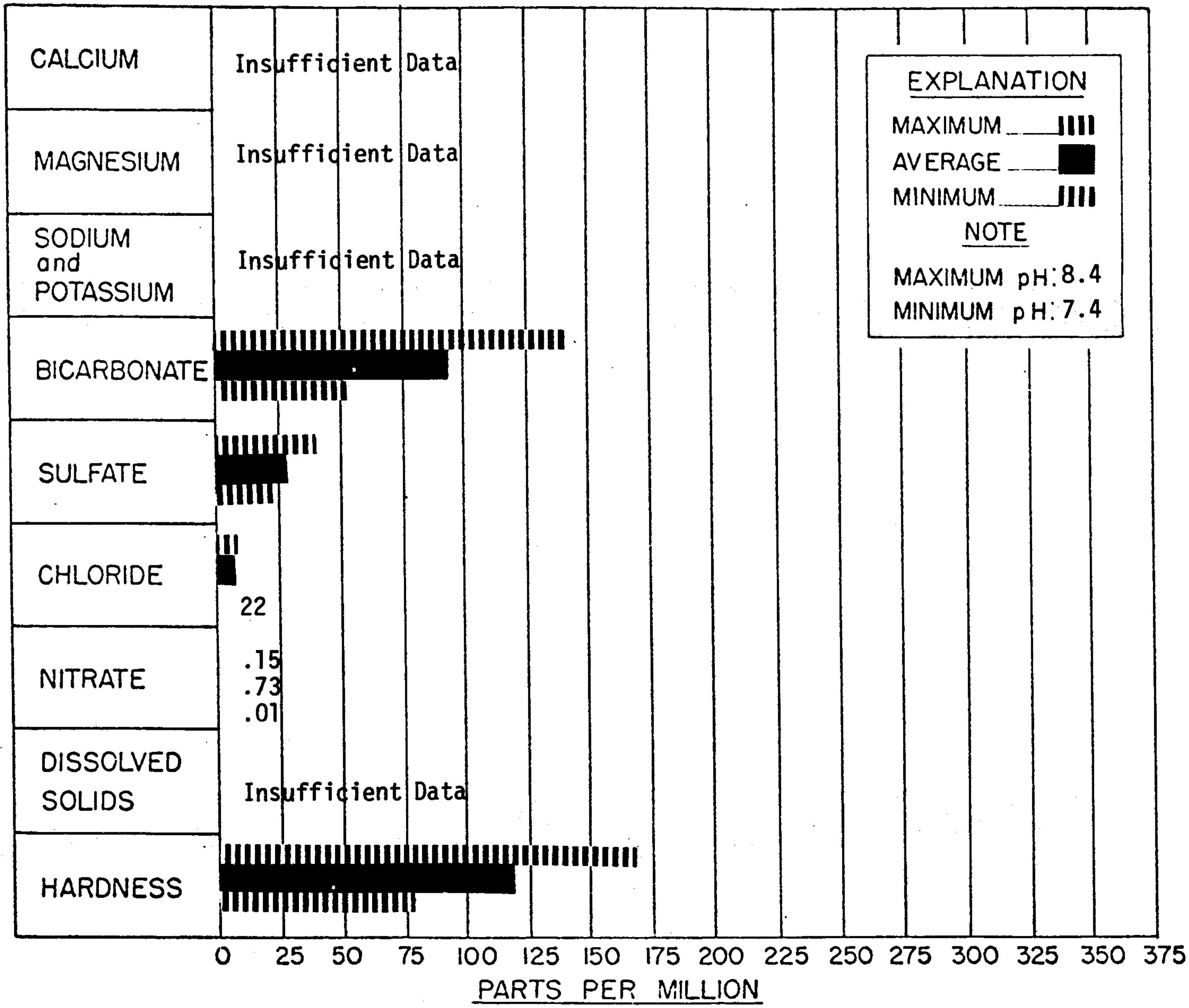


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Licking River at McKinneysburg

Period of Record 10-59 to 10-73

Figure I-3



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

Licking River at McKinneysburg

Period of Record: 1-73 to 10-73

Figure I-4

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20-25 parts per million as an average value.

The two sampling stations were used to depict the general chemical water quality for the Licking River basin reflect two different situations on the river.

Salyersville was selected to determine the effect of coal mining on water quality. This station is near the headwaters and above Cave Run Reservoir, and shows a wide variation in chemical quality partly due to the relatively small drainage area. That area is totally within the eastern coal field and fluctuations at the Salyersville station indicate the effects of coal mining and oil field operations on water quality. The effect of coal mining and oil field productions is illustrated principally in Figure I-2. The extreme variation in all parameters in comparing the average to the maximum indicates the influence of sporadic discharges which impacts water quality primarily at low flow periods. The production of coal in the Licking River Basin is low as compared to the coal reserves. Oil field production is primarily limited to recharged well production which is limited. Both of these developments reflect the primary influence of water quality, particularly at times of low flow. Since the average values are much as would be expected without oil or coal production. Figure I-2 indicates that the water is approximately an average type water when looking at the average values.

McKinneysburg, the other station was selected to indicate general chemical water quality, of the majority of the drainage basin (62%) and the effects of Cave Run Reservoir.

The water is classified as soft, moderately hard, hard, and very hard due to the concentration of certain ions, primarily calcium and magnesium. The range of hardness is 121 mg/l + 180 mg/l with an average of 136 which is a hard water.

The impact on water quality from Cave Run Reservoir at McKinneysburg is clearly illustrated by comparing the graphs of McKinneysburg and Salyersville. All parameters decrease at McKinneysburg which demonstrates the effectiveness of water reservoir impoundments for quality control of the general chemical quality of water and the ability of a reservoir to iron out or stabilize imparted chemical quality from the exploration of mineral resources such as coal and iron field developments.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

The trace chemicals results were from samplings at the Kenton County water district and in the Licking River Basin the water quality falls within the Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemical degradable waste impost a load on the dissolved oxygen resources of a stream. Such waste loads are considered to have an adverse effect on water quality when they cause the dissolved oxygen concentration of the water to drop below the Kentucky water quality standard of 5.0 mg/l. Approximately 1,000 miles of stream length were studied using a model to determine waste load allocations. The model was developed in the Kentucky Continuing Planning process for River Basin Management Planning. Using this model it was determined that approximately 384 miles are affected by treated wastewater. Of the 384 miles 51 miles are affected by industry, 90 miles by municipal sewage treatment plants and 243 miles are affected by other sources such as schools, trailer parks, motels, etc.